THE JOURNAL OF DOCUMENTARY REPRODUCTION

A QUARTERLY REVIEW OF THE APPLICATION OF PHOTOGRAPHY AND ALLIED TECHNIQUES TO LIBRARY, MUSEUM, AND ARCHIVAL SERVICE

The Present Status Of Equipment and Supplies For Microphotography

A report prepared for the Committee on Scientific Aids to Learning

By

VERNON D. TATE

Volume I
Number 3

Summer 1938

In Two Parts
Part Two

The need for an independent, critical, impartial journal in this field, published on a coöperative non-profit basis, has been felt by scholars, scientists, archivists, librarians, editors, authors, and other concerned groups. This JOURNAL, in attempting to meet this need, urges other periodicals to continue disseminating helpful news concerning scientific aids to learning, and seeks their coöperation, as its editors and publishers are motivated only by the spirit of scientific inquiry and service to scholarship.

The Editorial Board is assisted by members of several organizations interested in the scope of a professional periodical devoted to the use of photography and related processes in reproducing materials in print and manuscript form. Improvements and new procedures are appearing so rapidly that a central source of information is essential, particularly if science and scholarship are to receive the greatest benefits from the application of these means to definite educational ends.

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A quarterly review of the applications of photography and allied techniques to library, museum and archival service

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This publication is sent you with the compliments of the Committee on Scientific Aids to Learning, 41 East 42nd Street, New York, N. Y.

An acknowledgment of receipt will be appreciated; comments will be welcomed.

THE PRESENT STATUS OF EQUIPMENT AND SUPPLIES FOR MICROPHOTOGRAPHY

The mechanical side of microphotography is now in process of rapid development. Hand built or adapted apparatus, with the utilization of supplies and techniques developed for other purposes, is giving way before the advance of specially designed and constructed precision equipment and supplies specifically intended for microcopying. We are still too near the elementary stages, however, for development to have congealed. Experimentation is rampant. As in the early stages of the radio industry, individuals and companies are building equipment and experimenting with designs in order to meet particular requirements and conditions, yet microcopies can now be made in practically any quantity desired, and may be used in a variety of ways. Cost factors for the reproduction of textual materials are far below anything previously known. Notwithstanding all of the progress made thus far, both from the standpoint of the material development of the technique and from that of its application, only the outer fringes of the subject are being explored.

Many are prone to regard microphotography as a new development, although this assumption is entirely without foundation. Microphotography under a different name may be traced backward almost a hundred years, while over sixty years ago a true large scale microphotographic enterprise was undertaken. Scholars, scientists and others interested in the technique of research frequently considered the possibilities inherent in miniature facsimile reproduction on film or paper, and in some cases actual work was done. However, two great obstacles barred the way.

First, there was the cost of the process which was considerable; and, second, the manipulation which, although not difficult for the professional or even the advanced amateur, was almost out of the question for the average scholar, librarian, or research worker. Conventional copying with large cameras by professionals and some amateurs, together with full size or slightly reduced size photocopying by machine on paper, using the technique which has become known from a trade name as "photostating," met scholarly demands at a price which, while not cheap, represented economies over previous processes.

In the last decade the renaissance of textual copying at considerable reductions known variously as microphotography, microcopying, or microfilming may be attributed to several factors. The first was the availability of great quantities of excellent film at a low price. The second was the growth of the miniature camera, which, by reason of its compactness and versatility, the multiplicity of possible adaptations, the ease of operation, and a wave of publicity, resulted in a vast increase in amateur miniature photography. The third was the pioneering ventures of certain large companies in the commercial application of miniature record making. The fourth was the tremendous growth and distribution, almost to stultification, of printed and processed documentation resulting from improved cheaper methods of printing and duplicating. The fifth was the need for preserving important records which had been made on impermanent bases. The sixth was the assurance that properly made, processed and stored microcopies are as permanent as letter-press printing on rag stock paper.

The mechanical aspects of microphotography may be considered under several headings. An original is photographed by a camera, or photographic machine, wherein light and sensitive material are combined. Processing makes the invisible latent image produced in the camera visible and permanent. The original negative may then be used, reproduced, and stored in

a variety of ways. It is proposed to examine the equipment used in each step, then consider alternative procedures, in an attempt to delimit present progress and to indicate possible future developments in so far as may be practicable at this time.

CAMERAS

The appended Chart I illustrates, graphically, some of the characteristics of the better known cameras which have been used for microphotography. The cameras are tabulated as follows: Under "kind" each camera is considered as adapted or special. An adapted camera is one which was built for another purpose but which can be used, when equipped with suitable accessories, for textual microphotography. A special camera is one which has been constructed specifically for microphotographic work. "Film size used" refers to the width of film, and is customarily expressed in terms of millimeters (which is abbreviated mm.). "Capacity" means the amount of film which may be loaded into a camera at one time. For the smaller cameras it is usually given in terms of exposures, and for the larger in footage. For example, there are 800 double frame and 1600 single frame exposures per 100 feet of 35 mm. film. The term "perforations" refers to the holes stamped out of the edges of the film. They are used in motion picture practice to permit the film to be advanced rapidly in the camera, for machine processing and for projection, and have been used frequently in microphotographic cameras. Film is classified as single, double or non-perforate as it has perforations on one edge, both edges or no perforations. The "frame size" indicates the length of the image on the film. Single 35 mm. frames, borrowed initially from the motion picture industry, are approximately one inch wide and three quarters inch long, while a double frame is twice this length with the same width, or one inch wide and one and one-half inches long. Variable proportional frames are those which do not adhere to these

CAMERA	KIND	L- E	NO. BUILT TO DATE	WHERE BUILT	MADE BY
Argus	Adapted		Production	U.S.A.	International Research Corp. Ann Arbor, Mich.
Cinescopie	"		"	Belgium	La Cinescopie S.A. Bruxelles
Contax	"		"	Germany	C. Zeiss
Leica	"		"	"	E. Letiz, Inc.
Leica (Model FF)	"		"	"	E. Leitz, Inc.
Sayce-Watson	"		est. 25	England	W. Watson & Sons, Ltd. London
Ludwig-Ott	Special	t to ier	est. 12	U.S.A.	Ludwig & Ott New Haven, Conn.
Minigraph	"	old licy ced	est. 18	U.S.A.	International Filmbook Corp. New York, N.Y.
Photorecord	"		Production	U.S.A.	Folmer Graflex Corp. Rochester, N.Y.
Saint Rat-Seidell	"	t to ier	est. 6	France	A. Seidell & M. L. de Saint Rat Paris
Record Registry	"		est. 10	U.S.A.	Record Registry Corp. Indianapolis, Ind.
Reducagraph	"		est. 4	U.S.A.	National Microfilming Co. South Norwalk, Conn.
Draeger (Model I)	"	t to ier	est. 4	U.S.A.	R. H. Draeger (under license Wash., D.C. from The Chemical Foundation)
Draeger (Model II)	"		est. 6	U.S.A.	"
Film Fotokopist	"		est. 12	Germany	Fotokopist Berlin
Film-a-record (Photocopier)	"		est. 100	U.S.A.	Remington-Rand, Inc. Buffalo, N.Y.
Holbrook microcamera	"		est. 4	U.S.A.	Holbrook Microfilms, Inc. New York, N.Y.
Recordak (Commercial)	"		Production	U.S.A.	Eastman Kodak Co., for the Recordak Corp. Rochester, N.Y.
Recordak (16 mm. bound vol. copying)	"		est. 6	U.S.A.	"
Recordak (Newspaper)	"		est. 12	U.S.A.	"
Recordak (35 mm. bound vol. copying)	"		est. 12	U.S.A.	"

Chart I

SUMMARY OF MICROPHOTOGRAPHIC CAMERAS

CAMERA	KIND	FILM SIZE USED	CAPACITY	PERFORATIONS	FRAME SIZE	FILM ADVANCE	EXPOSURE	PORTABLE	BOOK HOLDER	ESTIMATED OPERATING SPEED	RESULTS (in expert hands)	ESTIMATED COST	AVAILABLE	NO. BUILT TO DATE	WHERE BUILT	MADE BY
Argus	Adapted	35 mm.	35 exposures	Double	Double	Hand	Hand	Yes	No	70 pages per hour	Fair	Outfit $50	Yes	Production	U.S.A.	International Research Corp. Ann Arbor, Mich.
Cinescopie	"	"	25 feet	"	Single	"	"	"	"	100 pages per hour	Good	Outfit Bel. fr. 2000	"	"	Belgium	La Cinescopie S.A. Bruxelles
Contax	"	"	35 exposures	"	Double	"	"	"	"	150/hr.	Excellent	Outfit $225	"	"	Germany	C. Zeiss
Leica	"	"	"	"	"	"	"	"	"	"	"	Outfit $200	"	"	"	E. Letiz, Inc.
Leica (Model FF)	"	"	33 feet	"	"	"	"	"	"	175/hr.	"	Outfit $250	"	"	"	E. Leitz, Inc.
Sayce-Watson	"	"	40 exposures	"	Single Double	"	"	"	"	175/hr.	"	£36	"	est. 25	England	W. Watson & Sons, Ltd. London
Ludwig-Ott	Special	"	100 feet	"	Single Double	"	"	"	"	300/hr.	"	$225-310	Built to order	est. 12	U.S.A.	Ludwig & Ott New Haven, Conn.
Minigraph	"	"	100' (200' available)	"	Single	Automatic	Automatic	No	Yes	500/hr.	Good	$325-375	Co. sold no policy announced	est. 18	U.S.A.	International Filmbook Corp. New York, N.Y.
Photorecord	"	"	100'	"	Single Double	"	"	Yes	"	"	Excellent	$265-315	Yes	Production	U.S.A.	Folmer Graflex Corp. Rochester, N.Y.
Saint Rat-Seidell	"	"	"	"	Double	"	Hand	No	Yes	300/hr.	Fair	$225 plus carriage and duty	Built to order	est. 6	France	A. Seidell & M. L. de Saint Rat Paris
Record Registry	"	"	200'	"	"	Automatic	"	"	No (in process)	500/hr.	Excellent	$585-650	Yes	est. 10	U.S.A.	Record Registry Corp. Indianapolis, Ind.
Reducagraph	"	"	"	"	Single Double	"	"	"	Yes	800-1000/hr.	"	$995	Yes	est. 4	U.S.A.	National Microfilming Co. South Norwalk, Conn.
Draeger (Model I)	"	35 mm. (70 mm. available)	"	"	Single Double	"	"	"	"	300/hr.	"	$1500 (?)	Built to order	est. 4	U.S.A.	R. H. Draeger (under license Wash., D.C. from The Chemical Foundation)
Draeger (Model II)	"	16 mm. 35 mm.	"	"	Single Double	"	"	"	"	1000/hr.	"	$2500 (?)	"	est. 6	U.S.A.	"
Film Fotokopist	"	35 mm.	60 meters	"	Double	"	Hand	"	No	400/hr.	"	R.M. 1550	Yes	est. 12	Germany	Fotokopist Berlin
Film-a-record (Photocopier)	"	16 mm.	100'	Single	Variable proportional	"	Automatic	"	No	2000/hr.	Good	$1650 or rented	Yes	est. 100	U.S.A.	Remington-Rand, Inc. Buffalo, N.Y.
Holbrook microcamera	"	16 mm. 35 mm.	100', 400' or 1000'	Single Double Non-perf.	"	"	"	"	No (in process)	1200-1800/hr.	Excellent	$1800-2000	Yes	est. 4	U.S.A.	Holbrook Microfilms, Inc. New York, N.Y.
Recordak (Commercial)	"	16 mm.	100'	Single	"	"	"	"	"	3000/hr.	Good	Rented not sold	"	Production	U.S.A.	Eastman Kodak Co., for the Recordak Corp. Rochester, N.Y.
Recordak (16 mm. bound vol. copying)	"	"	"	"	"	"	"	"	Yes	1500/hr.	Excellent	Rented not sold	"	est. 6	U.S.A.	"
Recordak (Newspaper)	"	35 mm.	"	Single perf.	"	"	"	"	No	1500-2000/hr.	"	Sold only to U.S. Govt. $5750	"	est. 12	U.S.A.	"
Recordak (35 mm. bound vol. copying)	"	16 mm. 35 mm.	"	Single Double Non-perf.	"	"	"	"	Yes	1000-1500/hr.	"	Rented, sold only to U.S. Govt. $5750	"	est. 12	U.S.A.	"

dimensions but instead use only enough film to accommodate the original being microfilmed. They are intended to conserve the sensitive material and are frequently found on the larger and on the rotary cameras. "Film advance" means the method of bringing a fresh film surface into position for exposure. "Exposure" refers to the method by which a measured amount of light is permitted to fall on the sensitive film. In the Chart reference is made to the method of operating the shutter. In any case a hand or other motion is required to actuate the shutter, yet some cameras provide electric, pneumatic or other machinery for opening the shutter, hence the operator need merely touch a button or valve. If the exposure is made by a hand operation, as using a cable release, it is indicated as "hand," while if the actual shutter motion is provided mechanically, the operation is considered as "automatic." "Portability" is a relative term which, in this study, will refer to the ease with which equipment may be moved. If the unit is compact and may be carried by one person easily, it is considered portable. Practically all of the cameras listed are movable, in that they may be transferred from place to place. In the succeeding column notation is made of the presence or absence of a "book holder." Practically all of the special cameras have book holders, or have designs in process of manufacture. The "estimated operating speed" is particularly difficult to determine, for this factor varies with the kind of copy being made, the size, age, and nature of the material, the operator and many other factors. An effort has been made to calculate a normal working speed for a skilled operator with good copy and favorable working conditions. It is an approximate figure based on experience and reports, and may be found to be somewhat in excess of average speeds. "Estimated cost" figures must be given, for in the case of the adapted cameras several kinds of alternate equipment may be used, thus increasing or decreasing the cost. Larger cameras built to order

as were the Draeger Models I and II probably cost more than if built at the present time. Under the heading of "available" reference is made to the possibility of obtaining one of the cameras or machines immediately. Those which may be secured at any time are so noted, while those which must be built to order or are not available for one reason or another are likewise indicated. Some companies prefer to rent their equipment, and will sell only to the United States Government which is prohibited by law from renting machines for more than ninety days unless special authorization is procured. Other concerns have a combined or optional rental and sale policy. The column entitled "number built to date" represents an estimated total of all machines constructed up to June 30 of this year. In the case of some of the popular adapted cameras and special commercial machines it is impossible to obtain an accurate figure, hence, they are labeled "production." This does not mean, however, that other special microphotographic cameras are not being manufactured on a production basis. The two final columns entitled "where built" and "made by" are self-explanatory.

An analysis of the Chart reveals three general classifications of equipment. First, there are the adapted cameras. These are generally available, and may be fairly expensive or quite cheap. They are portable, hand operated, and slow. For the most part they are capable of rendering excellent service in experienced hands. The film capacity is limited as is also the output in microcopies. Examples include the German Contax and Leica, the English Sayce-Watson,[1] the Belgian Cinescopie, and the American Argus, to which might be added the Kodak Retina and many

1. Exception may be taken to the consideration of the Sayce-Watson as an adapted camera. It is so included here, as initially, it was intended for use in making lantern slides. With equal justification it might be considered as a transition type between the adapted and the special cameras.

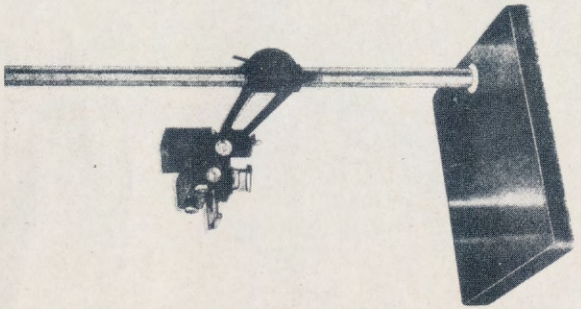

Plate II. Sayce-Watson Camera.

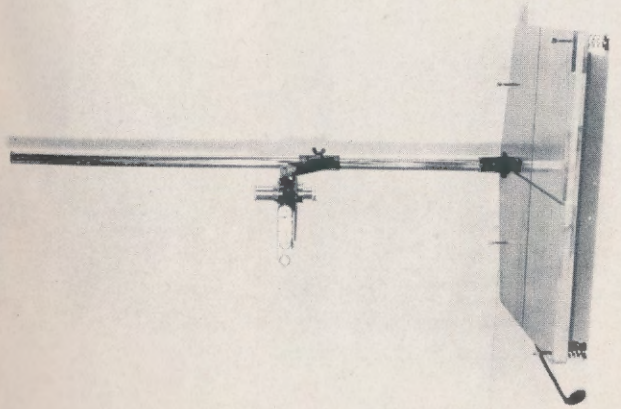

Plate I. Leica Camera with stand and attachments for copying. Note spring mounting of copy board, focusing magnifier and sliding focus copy attachment. No lights shown.

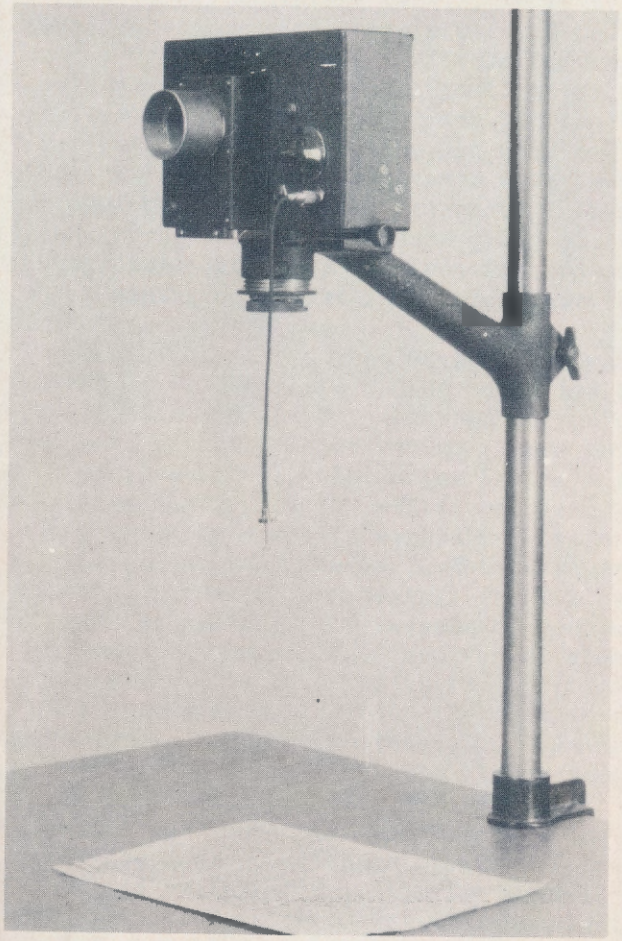

Plate III. Ludwig-Ott Camera. Note clamp for attaching upright to table. Visual focus and copy orientation device appears on front of camera.

others. Almost any miniature camera, in fact, may be used for microcopying and therefore could be included. Cameras of this type are particularly useful for the individual scholar or a small institution wishing to do limited amounts of microcopying in conjunction with other work. At this writing, it does not appear that there will be any great advance made in textual microphotography with these cameras. They have served their purpose in introducing and publicizing microphotography, but they may continue to serve as excellent training equipment from which operators may graduate to special equipment.

A selection of the best adapted cameras would be difficult. Probably the choice would lie between the Contax, Leica and the Sayce-Watson if price were not an object, with the Leica having a more universal selection of accessories, the Contax having a removable back which can be used for miniature glass plates, and a lens which by some is considered superior to that of the Leica, and the Sayce-Watson having more specialized adjustments for copying. The use of other cameras might be dictated by reasons of economy; and their efficiency in terms of those mentioned above compares roughly with the ratio of their initial costs.

The second group includes the smaller special cameras designed for microphotography. Among these are the Ludwig-Ott, Minigraph, the Photorecord, the Record Registry and the Saint Rat-Seidell. All of these may be considered as products of the United States, for the S.R.S., although built in France, was designed by and built for Dr. Atherton Seidell of the U.S. Public Health Service. The characteristics of these machines include a large film capacity, rapid operation, versatility, and many refinements especially for documentary copying.

The Ludwig-Ott camera[2] is less completely

2. Two distinct types have been built. The first models were partially constructed of wood, while the second models are made of metal. The New York Public Library, Harvard Library and Yale own and use these machines. One has recently been ordered for card reproduction in Tahiti.

mechanized than the others, and is the result of several years' experimentation at Yale University. It is hand built to order at a moderate price, and in skilled hands is capable of rendering excellent service. A well-corrected lens, visual copy orientation and focus, together with ease of operation are featured. It has had but limited distribution, however, and is rather difficult to obtain, for orders are filled upon receipt and the parts are made up individually. Each machine incorporates improvements over others previously built.

The Minigraph was produced by the International Filmbook Corporation (now extinct), and in one sense is an adapted camera, for the basic mechanism, lens and chassis of the French Sept were utilized. Several second-hand Sept cameras were purchased and converted. The Minigraph is only semi-portable, and for practical purposes may be considered as a non-portable piece of equipment. It possesses certain very desirable features, including fully automatic operation, light control, book cradle and many refinements of design. It also has serious limitations, among which may be mentioned restriction to single frame size and a tendency toward vibration. According to latest advice, eighteen of these cameras were built or were in process when the International Filmbook Corporation ceased operations. The new owner of the assets of the concern has not yet announced a policy with regard to his purchase. In its present state it is unlikely that the camera, even if marketed, would be completely satisfactory except for limited work of a specialized nature.

The Photorecord camera, manufactured by the Folmer Graflex Corporation, is the first production model of a precision microfilming camera to appear on the market. The result of several years' experimentation in the factory and in the field, this machine offers many desirable features. It is completely portable, for all of the standard equipment fits into a carrying case which becomes the base when opened,

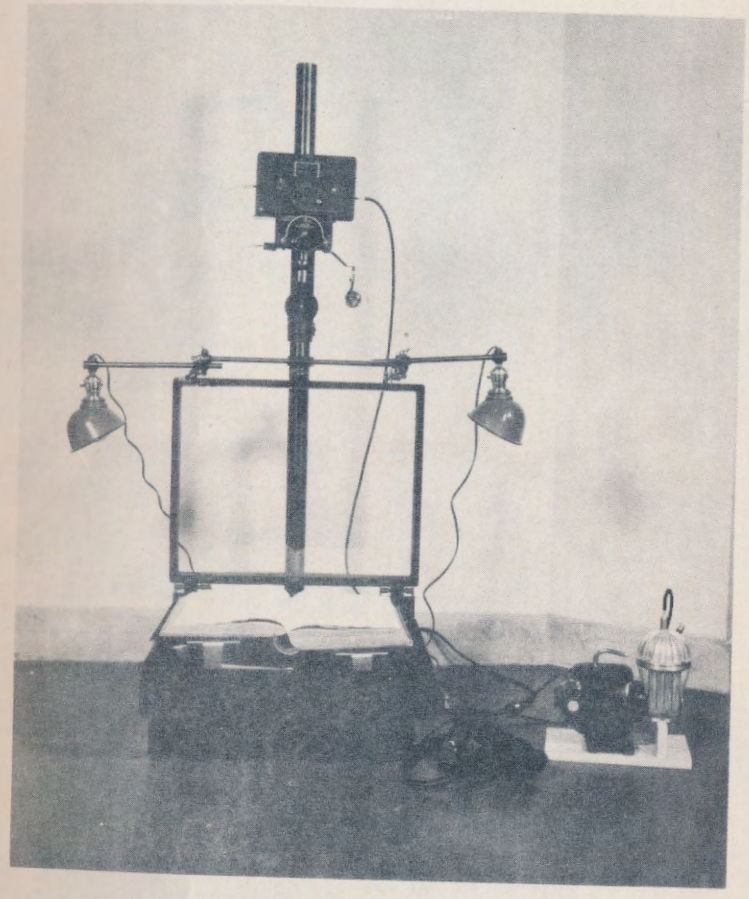

Plate IV. Photorecord Camera with book holder and motor compressor accessories. Note pedal valve to make exposure, air tubing for pneumatic cycle and focusing dial on front of camera.

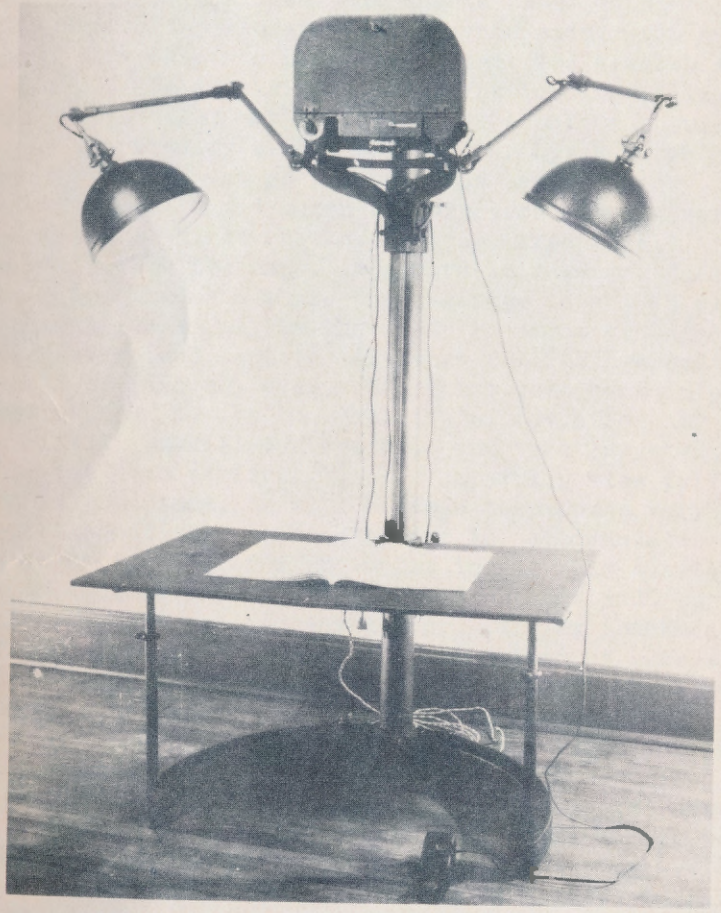

Plate V. Record Registry Camera. Note copy holder which can be raised or lowered, and automatic electric timer shown on lower left-hand corner of camera.

and the total weight is about 50 pounds. It is versatile, for both single- and double-frame exposures on 35 mm. double-perforate film may be made. In addition, cut film and plate magazines are available in 2 1/4 x 3 1/4 inch size. Daylight loading film in 100-foot lengths may be obtained. A unique pneumatic cycle operated by a foot bellows, or by a motor compressor which may be purchased as an accessory, advances the film and makes the exposure automatically, leaving the hands of the operator free at all times to manipulate the copy. A removable magazine facilitates loading, and while the magazine is not in place a ground glass may be inserted to allow visual copy orientation and focus. Although the Photorecord is highly mechanized, every effort has been made in perfecting the design to facilitate operation by the relatively unskilled operator, and to a large extent this has been achieved. If a careful novice follows the instructions, he will be able to produce very acceptable copies. A book holder to accommodate open books up to 19 1/2 x 26 inches in size is available as an accessory. A pressure adjustment and spring supported platens compensate for varying thicknesses of books being reproduced. In addition a removable platform allows unbound materials to be copied under the pressure of the glass top of the book holder.

The Record Registry camera, developed by Mr. J. Q. Kerrins for the Record Registry Corporation, is a very recent addition to the available special microphotographic cameras. Several individual models were built and tested before this design was made available for limited sale. The Record Registry Corporation operates a general microfilming service throughout the middle west, and specializes in the reproduction of county records for title and abstract purposes. In a sense this camera reflects these requirements. It is movable rather than portable (weight 95 pounds), and is electrically operated. Either alternating or direct current may be used. A book cradle for this machine may be procured but is not yet in

production. Visual copy orientation and focus together with a new electrical timing attachment are features. Daylight loading magazines are also provided. The fixed double-frame size might seem to constitute a defect, but single-frame operation can be incorporated on special order.

The Saint Rat-Seidell camera was designed by Dr. Atherton Seidell and built in Paris under his direction in cooperation with M. L. de Saint Rat. In basic design this camera resembles the earlier model Photorecord except that it is not portable and contains certain innovations intended to equip it for the copying of material in scientific books and periodicals. As the copies made with this machine are considered only for temporary use, little effort is expended in obtaining a precision product; hence, the results may be considered only as fair.[3]

The smaller capacity special microfilming cameras seem destined for widespread adoption. They require a low initial investment and are capable of producing a considerable amount of good work. The portable cameras of this type are useful for field work or for general use in medium sized and smaller institutions. Even large organizations will require them to supplement other equipment. Individual scholars may take cameras of this type to the location of desired materials and secure ample documentation in a few months for several years of intensive work.

The choice of a camera of this type would fall between the Photorecord and the Record Registry cameras. Both are available. The former is portable, the latter movable. The Photorecord is cheaper and

3. Two models of the Seidell camera were made. Yale University Library, the University of Chicago and the Maison de la Chemie in Paris acquired Model I cameras. A fourth was brought to the United States and subsequently taken to Tokio, Japan. Model II, a considerable improvement over Model I, is used by Bibliofilm Service in Washington, D.C., and two others are in use in Paris, one at the Bibliothèque National and another at the Association des Chimistes de Sucrerie.

Plate VI. Commercial Recordak in operation filming index cards 5x8 inches in size.

Plate VII. Film-a-record Camera in operation filming bank checks.

is capable of using different frame sizes and film sizes as well as plates and cut paper. The Record Registry machine is larger and more specialized. It would seem that the features of ready portability and versatility would favor the adoption of the Photorecord by scholars and scientists as well as institutions requiring a portable machine to supplement other equipment. The Record Registry machine would be better adapted for long runs in fixed locations.

The third classification of cameras, that of high-speed production units, includes the Draeger cameras, the Eastman Kodak-Recordak machines, the Film Fotokopist, the Film-a-record, the Holbrook Microcamera and the Reducagraph. These machines are intended primarily for commercial use or for large-scale scholarly operations. They may be subdivided into two classes: rotary and conventional.

The rotary and similar machines, designed for bank check work initially, are very simple in operation. Fully automatic, they are capable of attaining great speed. In addition they are suited for unskilled operation. Only loose materials or thin pamphlets may be copied. Originals are fed into a gate or slot; then they pass over a rotating drum, or other device, and are automatically photographed and delivered into a hopper in the same order in which they entered the machine. Two makes exist for 16 mm. film: the Commercial Recordak and the Film-a-record. The 35 mm. Newspaper Recordak, also a rotary machine, is used with larger originals.

The Commercial Recordak of the Recordak Corporation has been widely used for business, industrial and scholarly documentation. Loose sheets up to 8 1/2 inches wide and of indeterminate length may be filmed rapidly and without damage to the original. There is one disadvantage in that fine wires are used to hold the originals in place while filming proceeds. Images of these wires appear on the negative film as minute white lines, and in particular cases may obliterate a letter or word. For ordinary work, however,

these do not constitute an objection. Through the use of resistance controls and fine grain film, very good copies may be made with great rapidity. The widespread service organization of the Recordak Corporation is a great convenience. The Corporation does not sell its equipment at the present time except to the United States Government, but it may be rented for $50.00 per month for the first three months, and $30.00 per month for four months or more.

The Film-a-record is a recent addition to the 16 mm. loose sheet microfilming machines. It is the product of Remington Rand, Inc., and is the successor of the Photocopier. At present it is adapted for loose materials up to 4 1/2 x 9 inches in size and will photograph one or both sides of a document automatically. Metal fingers flip the document over and impale it on a series of fine pins when versos are being copied; hence, the machine, in all probability, will not be suited for archival and most scholarly materials. It will serve very well for impermanent business and other documents within the above size limitations. A sale or rental policy has been placed in operation by the company. The machine sells for $1650 with a possible 15% discount, and rents for four months or less at $50.00 per month and over four months at $27.50 per month.

The 35 mm. rotary Newspaper Recordak,[4] made by the Eastman Kodak Company for the Recordak Corporation, is probably the finest machine of its type. Loose sheets, generally of large size, are fed into a framework or chute and are held plane on a rotating drum by means of air suction. A narrow band or slit of light illuminates a segment of the copy as it passes over the drum and the film moves synchronously with the drum thereby permitting originals of indeterminate length to be copied. A form eleven inches

4. Machines of this type are in use at the Eastman Kodak Company, Rochester, N.Y., and two have been acquired by the Bureau of the Census, Washington, D.C.

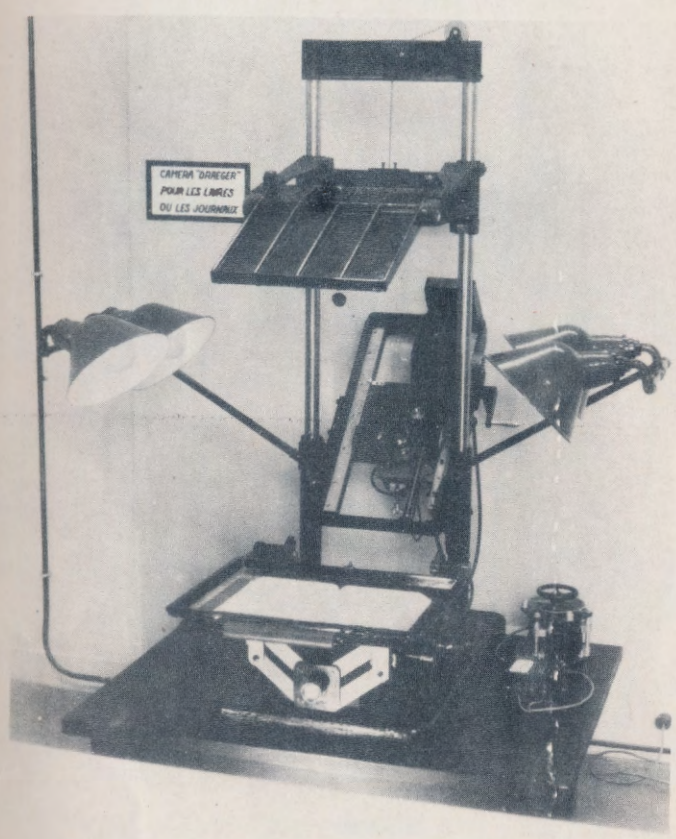

Plate IX. Draeger Camera, Model II. Note book cradle and unique method of eliminating tall stand by use of reflecting mirror. Light control right rear.

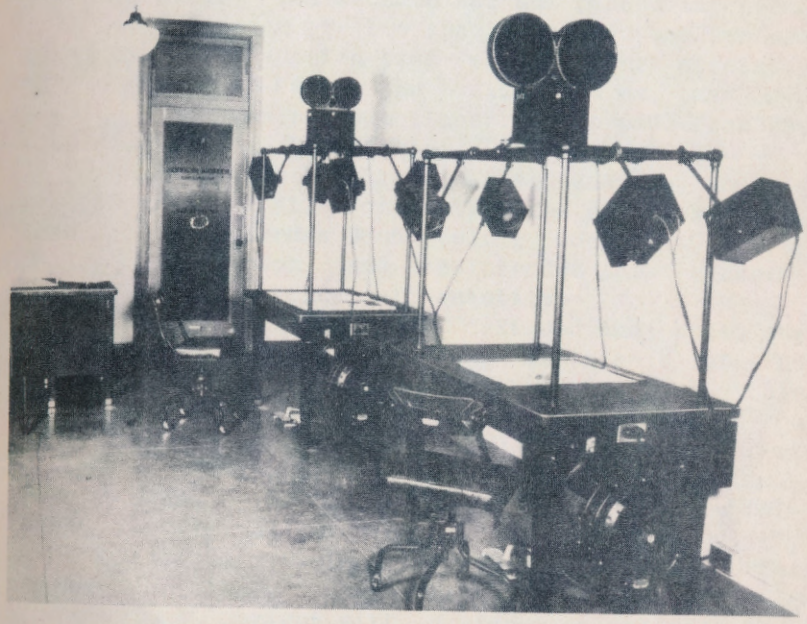

Plate X. Holbrook Microcameras. Note 1000 foot film magazines in place on top of cameras, condenser lighting system, and voltage control mounted right side of bases.

wide and 48 feet long was copied successfully on this machine. As its name would indicate, it was developed for use in copying newspapers, and the newspaper copying service of the Recordak Corporation is based on this machine. Operation is exceedingly simple and rapid. The machine has not passed into general use by reason of its specialization and immense capacity. The suction feed obviates the necessity for guide wires as in the smaller 16 mm. machine; hence, excellent reproductions may be made from the film produced on this machine.

The conventional high-speed cameras include the Draeger, the Film Fotokopist, the Holbrook Microcamera, the Recordak Bound Volume Copying Cameras and the Reducagraph, and are intended for the reproduction of bound volumes in quantity.

The Draeger cameras, designed and built by Dr. Rupert H. Draeger with the assistance of the Chemical Foundation, to whom the patents on this equipment were assigned, and the cooperation of the Navy Department in Washington, D.C., resulted from experiments in reducing scientific books and periodicals to film. Two models have been built, one following the generally accepted theory of construction, with a vertical tubular upright and arm holding the camera, the other,[5] deviating abruptly, by replacing the vertical upright with a mirror on shorter dual columns in order to avoid the need for a room with a high ceiling for camera operation. Both models are equipped with automatic film advance and exposure, book holders, light control, and other features for rapid and efficient operation. The Model II newspaper machine has a reciprocating carriage.

5. Cameras of the first model have been built for Bibliofilm Service, the Library of Congress (this machine contains provision for the use of 70 mm. film), the Surgeon General's Library, the Navy Medical School and the Bureau of the Census. One camera of the second model has been completed for the University of Chicago, another is ready to be shipped to Dr. Draeger in Peiping, China, if conditions permit, and two others are being assembled in Washington, D.C.

The Film Fotokopist, a German machine, follows a somewhat different design. It consists of a self-contained cabinet with an inset glass plate on the top against which the original is placed. The camera is mounted below. Film is moved into place automatically, but exposure is manual. There are several focusing points for material of predetermined sizes, each keyed to a distinctive color. No light control is supplied.[6]

The Holbrook Microcamera,[7] designed and built for Holbrook Microfilms, Inc., by Mr. John K. Holbrook, has been announced recently. It differs from many of the other large cameras in that four-point suspension of the camera is incorporated. A special camera head will accept varying lengths of film through interchangeable standard magazines. Lengths up to one hundred feet are loaded inside the camera, but large standard magazines, holding up to one thousand feet, may be fitted above the camera. Either 16 or 35 mm. non-perforate, single or double perforate film may be used. A proportional film feed which advances only the exact amount of film to accommodate the original being copied is included. Complete electrical operation, light control, and a wide film gate extending to 2 3/4 inches for 35 mm. film and 1 inch for 16 mm. film are featured. A book cradle is under design. For filming loose materials a suction blower over a perforated plate holds the copy securely in a flat position. Several of these cameras have already been built. A large contract microfilming job for the City of New York was recently completed with this equipment.

The Recordak Bound Volume Copying machines follow conventional designs and have vertical uprights to support the camera heads. Two models have

6. One of these machines is in use in the Staatsbibliotheck, and others have been placed in several foreign archives.
7. Described in the Journal of Documentary Reproduction, Vol. I, No. 2, p. 221.

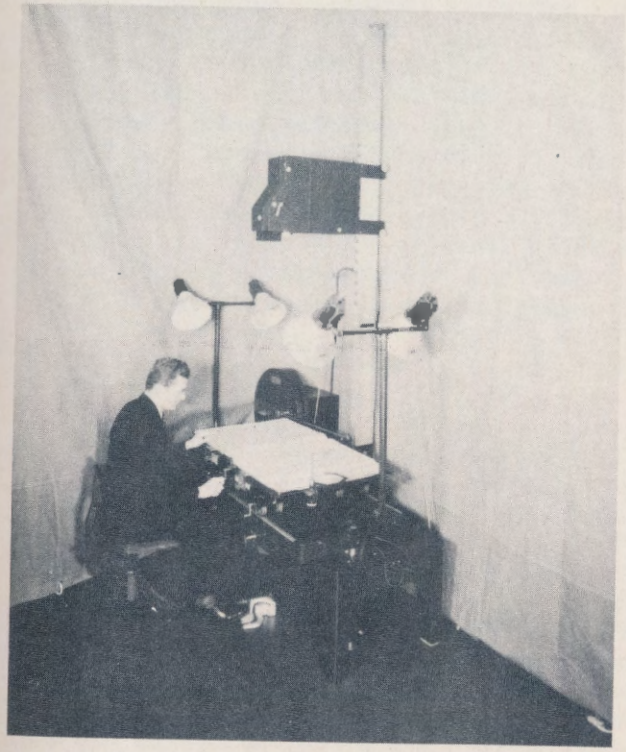

Plate XI. Recordak 35 mm. Bound Volume Copying Camera. Note reciprocating carriage.

been produced. The one for 16 mm. film may be considered experimental. It has been rented from time to time but has not been placed on the market. It is understood that this model will be replaced by a new one now being developed. The 35 mm. model, intended to copy bound volumes of large size, has been made available to the federal government.[8] It is completely automatic, and has a reciprocating carriage which allows alternate pages of large bound volumes to be copied rapidly. Accurate light control and a very ingenious coverage indicator, operating in conjunction with an adjustment whereby only sufficient film is advanced to accommodate the original being copied, promotes economical reproduction. Perforate or nonperforate film is used, and variable framing is featured, as indicated above. The Recordak Corporation prefers not to sell its equipment, except in special cases. Instead, a rental policy is in effect. The 16 mm. bound volume copying machine is rented for $200 per month for the first two months, $150 for the third and fourth months, and $125 per month thereafter, f.o.b. Rochester. The large 35 mm. bound volume copying camera may be rented for $250 per month for the first two months, $200 per month for the third and fourth months, and $175 per month thereafter, also f.o.b. Rochester. These prices include incidental servicing without charge. A trained operator will be furnished for $50 per week plus transportation and per diem living expenses. These machines have been sold in a few cases to the federal government, and the price for the smaller rotary machine was about $2750, and for the larger 35 mm. cameras, $5750.

The Reducagraph camera produced by the National Microfilming Company is in one sense an outgrowth of the Minigraph which is described elsewhere. Single or double perforate film is used, and material

8. One machine of this type was purchased by The National Archives, two others were acquired by the Bureau of the Census, and one by the Library of Congress, Washington, D.C.

may be filmed with the reading line either horizontal or vertical to the long axis of the film. Complete controls for lighting, automatic operation, and critical micrometer focusing are incorporated. A roller cradle is provided for the reproduction of large bound volumes. At the present time cameras of this type are being used in the contract microfilming service offered by the National Microfilming Company. The sale price is $985.

Most of the large microfilming cameras are highly specialized, and some are rather difficult to procure. The Film Fotokopist is not precisely suited to production requirements as understood in this country, and, when the initial cost with the 45% import duty and transportation are totaled, the possibility of importation seems remote. The Draeger cameras were submitted to several leading manufacturers with a view to their production for the market, but no decision in this matter has been announced. Only four of the improved models were constructed or are in process, and, with Dr. Draeger on duty in China for the next three years, it seems unlikely that others will be built except under the pressure of special demand. The Film-a-record is at present the only 16 mm. loose sheet machine which may be readily purchased, yet it has never been used for scholarly and research work, and was intended for filming bank checks. The Holbrook Microcamera and the Reducagraph are obtainable.

The field for the largest cameras is rather difficult to delimit. Only a few have been constructed, for their high cost and large capacity render them suitable only for long-run quantity production, usually at high ratios of reduction. This condition is met in commercial work, and, to a certain extent, in academic work also. It seems likely that, while governmental agencies and the larger libraries will purchase equipment of this nature, other institutions will probably content themselves with the smaller, medium production, versatile units, and may attempt

to secure additional facilities, when needed, on a rental or contract basis. As indicated on the chart, cameras of this type require a large outlay, and few institutions can afford to invest this amount of money in a machine unless it is kept in constant use. There is some possibility that commercial copying firms, following the example of the title and deed copying services already in existence, may expand into regular contract copying agencies for academic or business firm alike. In this case the increased demand may lower the price of the machines.

Thus far nothing has been said about the many other microphotographic cameras which have been developed experimentally or for individual use. Motion picture cameras have frequently been converted for microfilming. An example of this type of adaptation is the camera developed by Edwards Bros., Inc., of Ann Arbor, and used by them to film English books printed before 1550.[9] The International Filmbook Corporation rebuilt a motion picture camera in their South Norwalk laboratories, and used it to film a considerable amount of material. Consumers Research, Inc., are said to have adapted a camera for their use. Mr. Kennedy, of Warren, Ohio, developed and built a microcopying machine to reproduce county records. In Seattle, Washington, the Filmograph Company evolved a camera for filming county records. Captain McCandless, of the U. S. Navy, did considerable record copying at the Navy Department with a slide-film camera which he developed in 1922. Titling and animation cameras, similar to those used for making animated cartoon motion pictures, have been used for documentary copying, particularly with flat sheets. The Bell & Howell titling camera is suitable for this purpose. These random examples serve merely as an indication of the extent to which adapted equipment has been, and is being, used for microphotography.

9. This project has now been transferred to University Microfilms.

Several improved microphotographic cameras now in process of design and manufacture. The Eastman Kodak Company has recently circularized libraries and large business concerns to determine probably demand for a large bound volume copying camera. If the canvass reveals sufficient interest, it is possible that a simplified model will be placed in production at a popular price. On the basis of experience gained with the 16 mm. bound volume cameras which were leased to the New York Public Library and others, the Eastman Kodak Company has recently demonstrated an improved 16 mm. bound volume copying machine which may be placed on the market. Progress in the design of a smaller, more universal machine, by the same company is reported. The details of construction, however, have not yet been made public. The Holloway Company has partially completed a model of a small 35 mm. electrically operated camera which may be placed in production. Before dissolution, the International Filmbook Corporation had perfected a new high-speed document copying machine of advanced design. Patents have been recently issued to Mr. Leonard Townsend on a large-scale high speed microphotographic machine, and a complete model is in prospect. The Pathé Corporation is experimenting with several cameras. A preliminary model of a loose sheet document copying machine built by this firm is reproduced as plate XII. Holbrook Microfilms, Inc., promise additional improved machinery. Remington Rand, Inc., is also developing other designs which will be added to the Film-a-record line. In Indianapolis a concern has built a bound volume copying camera of unconventional design and high capacity and is conducting further experiments before announcing a possible manufacturing policy.

The camera situation in microphotography may be summarized as follows: An adaptable camera may be secured within almost any price bracket. At least two special cameras which operate satisfactorily are readily available to the individual, the medium-sized institution and business concerns. Several large

Plate XII. Pathé Loose Sheet Copying Machine [incomplete model].

capacity machines may be obtained on a rental basis, and in some cases may be purchased. Progress in camera design is proceeding in the direction of simplification, universality and automatic operation.

SENSITIVE MATERIALS

Sensitive materials will be considered under their respective supports or bases. In microphotography, these are principally film and paper, although glass plays a minor part. At the present time film is the most popular medium for making negatives and positive prints. Paper is usually employed for enlarged projection prints, but has been used in other ways. Dr. L. Bendikson of the Huntington Library, and the Dutch Scientist, Dr. Van Iterson, mount contact paper prints from microfilm negatives for magnification reading. Another scheme involves the projection by reflection of microfilms on paper, or miniature printed texts made from microfilm negatives. Other supports or bases have been and are being used experimentally, but almost all of the work now being undertaken is done on film or paper.

Much, if not most, of the sensitized paper now being furnished is suitable for permanent records, but there are two film bases available: cellulose nitrate and cellulose acetate. The former is impermanent and is dangerous to store in view of fire, explosion and gas hazards, with consequent peril to human life. The latter, cellulose acetate, is suitable for permanent records, and is slightly less inflammable than ordinary paper. ALL MICROFILM COPIES SHOULD BE MADE ON ACETATE FILM.

Sensitive materials are prepared by coating a light-sensitive emulsion on a base. In the early days of microphotography, motion picture film was utilized for negative making. In fact the presence of large quantities of excellent cheap motion picture film was one of the great factors in the renaissance of textual microphotography, as has been pointed out elsewhere. At the present time, however, while motion

picture film is still used to a great extent, the demands of microphotography have resulted in the preparation of special emulsions.

Emulsions may be classified under four headings by color sensitivity as follows:

(1) Color blind or non-color sensitive
(2) Orthochromatic or partially color sensitive
(3) Panchromatic or fully color sensitive
(4) Special emulsions

Color blind is applied to the positive and special contrast films extensively used in the making of original negatives and film prints. Orthochromatic materials are employed for particular color problems in the original. Panchromatic films are used when a combination of color problems beyond the capacity of orthochromatic film is encountered. Special emulsions, including full color copying materia, infra red sensitive film, etc., are used for special purposes.

One of the problems in the selection of a film for microphotography is grain, which may be defined as the clumping tendency of the minute grains of silver in the emulsion caused by development or by the composition of the film itself. Fineness of grain is absolutely necessary in order to secure readable results. As the ratios of reduction increase, the problem of grain size increases also. The Eastman Kodak Company has developed Microfile panchromatic film as one answer to this problem. It is an excellent material but is, unfortunately, quite expensive. The Agfa Ansco Corporation has prepared two new films: Agfa Document, and Minnipan. These are now undergoing final tests before being marketed. Preliminary reports indicate that they will compare very favorably with Microfile, and the cost will be considerably less. Special positive films for making positive prints are also being developed, and may be obtained in some cases.

Sensitive paper has not kept pace with the growth of microphotographic film, probably because papers already marketed can be used advantageously, and are not expensive. To date, no special paper for the making of projection prints from microfilm has appeared. Brovira papers of the Agfa Ansco Corporation, P.M.C. and Insurance bromide made by the Eastman Kodak Company, Photocopying and other bromide papers made by the Haloid Corporation, and the photostat papers of the Photostat Corporation have been extensively used. The latter concern has recently placed a new thin base paper on the market under the name "Kind 869." It is quite inexpensive and produces excellent results. The Dexigraph division of Remington Rand, Inc., made some experiments in the use of paper and has developed book holding equipment for use with the Dexigraph. Several experimenters have been at work devising possible methods for reading paper microcopies, for they may be made with existing equipment. It is too early yet to forecast the probable outcome of these studies.

Ozaphane, a new sensitive material, has been recently applied to microphotography. It consists of light-sensitive diazo dyes which are impregnated in a transparent base.[10] The impregnation entirely replaces the customary silver emulsion which is coated on a base. The first samples were made on cellophane, but as this was found to be impermanent, cellulose acetate is now used. Ozaphane film is very slow and requires a special printer. It cannot be used in the camera for making original negatives. One most interesting property of this material is its ability to print direct, or in other words, a negative may be printed directly from a negative, and a positive from a positive. The film is developed in ammonia vapor,

10. A similar material on a paper base is marketed under the name, Ozalid. It is extensively used for "true to scale" plan, blue print and poster work, but has no significance in microphotography at the present time.

hence, is very easy to process and is not affected by water shrinkage. It is grainless and very high ratio microcopies may be printed upon it with excellent results. It is possible to alter the gamma in printing, thus, contrasts may be greatly increased or diminished at will. The material seems very suitable for making duplicate negatives or for positives for reading. It is quite cheap, and is in fact less expensive than silver film. As the dyes are impregnated through the surface of the support there is no emulsion to scratch or abrade. The National Bureau of Standards has conducted exhaustive tests of Ozaphane on cellophane base and is now engaged in investigating the present acetate base materials. Preliminary reports indicate that the latter may prove to be satisfactory for many purposes.

In summary, sensitive materials for microphotography are slowly being developed in response to growing needs. At the present time materials exist which can be used, but progress will undoubtedly be made in the relatively near future. There is great need for a methodical exploration of the present status of sensitive materials keyed to processing formulas and procedures. Films should be studied in their relation to definite problems encountered in copying originals of all kinds at various ratios of reduction. The problem of grain size with high ratios of reduction must receive attention. A thoroughgoing study of this nature would provide manufacturers with precise information of exactly what is needed by the technique, and, at the same time, would develop for users a chart or scale of available films, and the precise method of utilizing each type to best advantage in relation to definite problems. Manufacturers have declared themselves willing and anxious to cooperate in a plan of this nature, and it is to be hoped that such a study may be undertaken in the near future.

PROCESSING

The operation of processing makes the latent

image, formed on the sensitive material, visible and permanent. It may be considered as the second half of a highly interdependent reaction. If suitable copies are to result, processing must be carefully integrated with the film used, the kind of copy desired, exposure and other factors. The processing of microfilms is not difficult, but must be carefully conducted under standardized conditions if uniform results are to be achieved.

For the purposes of this study the processing of paper and other substances will be neglected, and attention will be concentrated on film.

Of the many methods of development, time and temperature is favored. Film is immersed in carefully compounded baths, maintained at a constant temperature, and allowed to remain for a predetermined time. It is then washed and dried. A recommended processing procedure for microfilms intended as permanent records is:

(1) Develop
(2) Rinse (water or acid-rinse bath)
(3) Fix
(4) Wash (in ordinary water)
(5) Refix in fresh fixing bath with or without hardener
(6) Wash for 15 minutes in ordinary water
(7) Wash for 15-30 minutes in distilled water
(8) Test residual "hypo" content; result must be negative
(9) Dry under controlled conditions.

This basic procedure is followed in both hand and machine processing. For microcopies not intended for permanent records, steps 5, 6 and 7 may be eliminated.

Hand processing of microfilm may be divided into two classifications: short length and long length. For the short lengths of about 35 exposures (approximately 5 feet), used in most adapted cameras, a variety of equipment, designed to appeal to the

miniature camera enthusiast, is available. The cost is moderate,[11] and practically any desired combination may be secured. Most of the types, however, are variations in the rack and tank or rack and tray method which will be discussed later. In emergencies no equipment other than a few developing trays may be used for short lengths.

The longer lengths of film, from 30-200 feet, require special devices. One of the most common consists of an oblong wooden, rubber or metal rack on which the film is wound. This rack is then immersed in deep tanks, or moderately deep trays. An outgrowth of this system is the so-called "comb" rack, which consists of two strips of wood or metal joined in the center at right angles with pegs or pins on the upper edges. The film is wound around these pegs or pins, and the rack is immersed in a developing tank, which is about three to four inches deep and varies in diameter with the length of the film being processed. An outgrowth of this method is the Stineman developing system,[12] which is the most common hand method of developing microfilm at the present time. The Stineman reel is a helical spiral made of stainless steel about 5/8 inch in height with the convolutions about 1/8 inch apart. Film is loaded on this reel, emulsion out, and developed in metal tanks about three

11. This equipment costs from $4 to $12 per unit. A standard reel and tank complete sells for $6.50.

12. Stineman System.

No.							
0	three	nesting	tanks	and	two	18' reels	$35.00
1	"	"	"	"	one	50' reel	$30.00
2	"	"	"	"	two	50' reels	$50.00
3	"	"	"	"	three	50' reels	$70.00
4	"	"	"	"	one	100' reel	$50.00
5	"	"	"	"	two	100' reels	$82.00
8	"	"	"	"	one	200' reel	$86.00

Tanks and reels may be purchased individually. A 50' reel costs $20, 100' reels, $32, and 200' reels, $50.

Plate XIII. Winding Film on Stineman Reel. The rewind spool is used to hold exposed film being wound on reel. The three nesting tanks hold the processing solutions.

inches deep. Reels accommodating 50, 100 and 200 feet are obtainable. The diameter of a 100-foot reel is about 24 inches. Three nesting tanks are also furnished. In careful hands the Stineman equipment is capable of rendering excellent service.

An alternate method, employing an "apron," is the Davidge developing system. This equipment is marketed under the name of the Hollywood Roto-Tank.[13] Essentially, it consists of an indented cellulose acetate apron, about the size of the film being processed, which is wound together with the film on a core or rotor. The indentations keep the film from touching during development. The rotor is then placed in a light tight tank and the handle rotated. Rapid, even developing is claimed in solutions half the normal strength. The apron, however, must be carefully washed and dried each time that film is processed before it can be used again. Some operators state that it is difficult to wash all of the chemical out of the apron. Roto-Tanks are available in sizes to develop 25, 100, 200, 400 and 1,000 foot lengths of 35 mm. film.

Insufficient attention has been paid to the drying of microfilms processed by hand. They are usually dried on large reels, on folding racks, or in emergencies merely stretched across a convenient open space.

Machine development for microfilms, particularly for the larger users, seems to be the ultimate

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13. Roto-Tank.

25' enclosed bakelite tank with 16 or 35 mm. apron,	$25.00
100' metal rotor with 35 mm. separator apron,	$65.00
200' " " " " " "	$95.00
400' " " " " " "	$150.00
1000' " " " " " "	$350.00
Triple compartment wooden tanks, 100' size,	$56.00
" " " " 400' "	$85.00

Monel and stainless steel tanks, $40 and $395.
Separator apron 19 to 45 cents per foot.

solution to the processing problem. Large-scale commercial operators have used continuous machines for some years with excellent results. The machines built for the Recordak Corporation are marvels of capacity, speed and excellence. Recently, the Holloway Company built a continuous developing unit for the University of Chicago which was used on the A.L.A.-University of Chicago-Paris Demonstration Project. It served very well despite some initial difficulties caused by poor packing for shipment. Experience gained with this machine enabled Mr. Herman H. Fussler, in cooperation with Mr. Jack Holloway, to design another for the University of Chicago microphotographic laboratory. Arrangements are being made for the building of another machine of a similar type for the Library of Congress Photoduplicating Service. Indications now seem to point to the availability of a continuous processing machine of simplified design intended particularly for microphotography at a cost of from $500 to $1000.

The basic design of a continuous processing machine is quite simple. A motor drive and a series of solution tanks with rollers or hangers is arranged so that film passes through the various solutions and baths at a fixed rate of speed, and thus may be controlled in development. The film is then discharged into a drying cabinet where heat and humidity are carefully regulated. Machines of this type are fairly expensive, but they do give good results when properly managed. A fairly large volume of film is required in order to justify the investment, as the speed of processing may range from four feet per minute upward. Continuous machines are non-portable, require careful installation and trained supervision.

In summary, processing equipment may be purchased at moderate prices and used to excellent advantage for small, medium and large scale operation. Progress is reported in the application of continuous processing techniques. There are several factors which should receive attention. One is the problem of drying film. The second is the establishment of a

possible central laboratory where the individual scholar could have his film processed at a nominal charge. A series of these processing stations should be created in the principal research centers of this country. The third is the need for the training of personnel to undertake processing work, but this will be mentioned in another connection. The fourth factor relates to the possible research plan suggested under the heading of "Sensitive Materials." Processing techniques and developing solutions should form an integral part of any research plan dealing with sensitive material.

UTILIZATION

Microcopies may be utilized in several ways. Negatives or positives may be read by making enlarged prints on paper, by magnification, or by projection.

Projection prints on paper, or enlargements as they are sometimes called, recreate the original of a textual microcopy in facsimile. The enlargement may be compared to a photostat, and may be the same size as the original, or may be larger or smaller as desired. The prints usually can be read by the unaided eye, and for scholarly purposes are identical with the original in value. The Bibliofilm Service furnishes enlargements, or "Photoprints," to customers on demand. A print 6x8 inches in size costs ten cents. The Library of Congress, in procuring documents for the history of the United States in foreign archives (Project A), obtained almost one million microfilm negatives, which were later enlarged to full size. The cost of making these prints varied with the location where the prints were made. Some made in France cost 6 cents, while others contracted for in this country cost 15 cents.

Projection prints are easy to use, for they are positive, that is, in black on white, and require no reading devices. Paper prints may be compared and annotated. On the other hand, they are expensive. If paper prints were to be made of all microfilms, many

of the potential economies in copying costs and storage space might be lost. For some purposes, however, notably deciphering and translating foreign manuscripts and books, or for card catalog reproduction, they may be necessary.

Equipment for making projection prints need not be extensive. An enlarger, in addition to the usual dark-room facilities, is required. Many enlargers are available. The Eastman Kodak Company sells a miniature enlarger, although it is not particularly well designed from the point of view of microphotography. The Folmer Graflex Corporation offers the Enlarg-or-Printer, and E. Leitz and Carl Zeiss each manufacture several models. The International Research Corporation markets an enlarger as a companion to the Argus camera, using the camera as an integral part of the unit. The J. G. Saltzman Company of New York has completed a professional unit which is exceedingly efficient. In addition, a great variety of German, French, Czechoslovakian, and Russian enlargers is flooding this country in response to the demand of miniature camerists. Some of the equipment is good and some is mediocre. Machines may be obtained for a few dollars or may cost several hundred. Individual requirements will dictate the choice. Among the better instruments are the Enlarg-or-Printer, the Leitz, Saltzman and Zeiss enlargers.

One development in the making of enlarged paper prints is particularly significant. This is the introduction of continuous projection printing machines. Several of these have been built, experimentally, throughout the country. The Eastman Kodak Company has one in Rochester, which, in conjunction with a continuous paper processing system, is capable of quantity production of prints of moderately good quality. The Folmer Graflex Corporation has been experimenting with a continuous film feed for their Enlarg-or-Printer, which will facilitate the production of paper prints, although these must still be processed by hand. J. G. Saltzman, Inc., has made up several

experimental film feeds for the Saltzman enlargers. These are electrically operated and provide advance and retraction through a simple control near the enlarging easel. The Photostat Corporation has developed an interesting unit which can be used to adapt a Photostat machine for projection printing from microfilms. It comprises a complete light source, optical system and film advance particularly designed for microfilm, and is mounted on the face of the Photostat machine to replace the usual lens and prism assembly. After careful focusing, the prints are made on photostat paper, which is rolled down and processed in the usual manner. If this attachment is used on a continuous machine, great speed is possible. The unit is obtainable, but as it is new at the present time, its potentialities can only be estimated. Mr. George A. Schwegmann, Jr., Director of the Union Catalogue and of Photoduplication Service of the Library of Congress, has made arrangement to secure one of the units for the Library, and his experience will afford a basis for definite conclusions.

It may be desirable at this point to indicate a related field of endeavor which may attain immense significance. This is the combination of microphotography with miniature printing, following the general plan outlined over a decade ago by Admiral Fiske, and the reading of the miniature printed paper copies by reflection projection in a special reading machine.[14] This may lead to the making of original paper reversed negatives for reading or to the use of paper contact prints from microfilm negatives instead of film prints. The work of Bendikson and Van Iterson previously mentioned is an example of a related

14. Some printed paper copies of originals reduced 10 diameters linear have been exhibited privately. If this system is adopted, it will introduce the publisher into microphotography, for edition printing is required in order to meet the initial costs, although the unit cost can be almost microscopic.

development intended for magnification reading which has been adopted on a limited scale.

The uses of paper in microphotography have not yet been fully explored. Contact paper prints are cheaper by about two-thirds than film prints and have other advantages as well. The introduction of stripping papers and other processes may provide a key to more widespread utilization, and it is certain that this development will receive greater attention in the future.

Chart II

EFFICIENCY OF CONSULTATION MEDIA

	Optical Magnification	Wall Projection	Reading Machine
Readable Ratios of Reduction	1-8*	1-27 (and up)	1-27
Efficiency for Checking	Good**	Fair	Good
Efficiency for Casual Consultation	Poor	Good	Excellent
Efficiency for Intensive Reading	Unsuitable	Fair	Very Good
Relative Speed of Consultation	Slow	Fairly Slow	Fairly Fast

*By use of binocular microscope this can be increased.

**For ratios up to 12-14 diameters reduction.

The original film negative, or a positive

film printed from it, may be used in one of three ways. These have been classified as:

(1) Optical magnification
(2) Wall projection
(3) Use in reading machines

Optical magnification reading, except with expensive binocular microscopes, is practicable only for the lower ratios of reduction, and increases in difficulty with any increase in the ratio of reduction. The top limit for magnification reading is about 12 diameters. The film is held over an illuminated sub-base, or placed so that it is illuminated by transmitted light from some source, and, with the aid of a lens of sufficient power, the material may be read.

Equipment for optical magnification reading varies in extent and price. The appended chart will portray some of the characteristics of representative devices of this type. For very low reductions a powerful reading glass may be made to suffice. Probably the lowest priced special equipment is that brought from France by Dr. Atherton Seidell, consisting of a lens, a film carrier, and a diffusing screen mounted in a bakelite case. The magnification is about four times, and the price is $1.50. It is distributed by the American Documentation Institute, Washington, D.C. E. Leitz manufactures a hand film viewer which sells for $12.60 in this country. A more elaborate device, with an illuminating system and a low and higher power lens, was available for about $50, but is no longer listed in current catalogs. However, Zeiss-Ikon manufactures a somewhat similar device for about the same price. The International Filmbook Corporation, shortly before dissolution, marketed a Fiskeoscope, with several accessories, at about $10 complete, which was moderately satisfactory. There have been several similar devices of various prices and degrees of accuracy placed on the market for the users of miniature cameras.

Chart III

TYPICAL OPTICAL MAGNIFIERS

NAME	MADE BY	WHERE MADE	MAGNIFICATION	ILLUMINATED SUB-BASE	DIFFUSING SCREEN	FILM CARRIER	COST	REMARKS
Reading glass	Various	Various	2-4x	No	No	No	$1-5	For very low ratios of reduction.
Seidell viewer	for A. Seidell	France	about 4x	No	Yes	Yes	$1.50	Suitable for temporary use—scratches film. Distributed by the American Documentation Institute and Science Service.
Leica film viewer	E. Leitz	Germany	about 5x	No	Available as accessory (1.50)	Yes	$11.10	Does not scratch film. Has film-notching device to indicate frames.
Large film viewer	E. Leitz	Germany	about 5x and 10x	Yes	Yes	Yes	about $40.00	Has supplemental lens for additional magnification (now obsolete).
Van Iterson reader		Holland	5x and 10x	Yes	Yes	Yes		Also used for reading paper prints.
Viewing magnifier	Carl Zeiss	Germany	6x and 10x	Yes	Yes	Yes	$35.00	Supplemental magnifiers available, has film-notching device.
Binocular microscope	Various	Various	1-40x upward	Can be fitted	Can be fitted	Can be fitted	$100.00 up	Used by Bendikson and others for reading paper prints.
Fiskoscope	International Filmbook Corp.	U.S.A.	4-5x	Can be fitted	Yes	Yes	$3.50 to $10.50	Stands, handles and reel holders can be fitted. Price varies with accessories desired.

Some individuals have constructed, or had built for them, magnifying devices of this type. Dr. R. H. Draeger built one for the Bibliofilm Service which is used to segregate and check orders. Dr. Amandus Johnson, of Philadelphia, made one of similar design for his use.[15] In Holland, a unit with illuminated sub-base and lens for reading film was made for Dr. Van Iterson, and received much favorable comment. Mention also should be made of the system envolved by Dr. L. Bendikson[16] of the Huntington Library. For reading film and miniature photographic prints he adapted a binocular low-powered microscope. This system has been followed by many scientists who use material photographed by the Bibliofilm Service.

Magnification reading, even of very low ratios of reduction, is not practical. It may be used to examine the film for defects, to check page numbers, for identification of rolls, or for very limited reading, but the eyestrain involved and the general difficulty of manipulation render it unsuitable for more extensive use. A magnification reader should have a good lens, and a film carrier which cannot damage the film. Probably the best instruments are the binocular microscopes, if available, or the Leitz hand viewer.

Wall projection has been used extensively by individual scholars, and to some extent by institutions. A projector and a screen, or convenient light-colored wall surface, are required. A darkened room is essential in most cases. Film is inserted in the projector and the image is thrown on the screen.

The essentials of a wall-type projector[17] are: an adequate lighting system, which does not emit enough heat to buckle, warp or damage the film; an

15. Illustrated and described in the Journal of Documentary Reproduction, Vol. I, p. 18.
16. See Library Journal, Vol. LVIII, pp. 911-913.
17. See Carruthers, R. P., "Essential Features of Wall Type Projectors," Journal of Documentary Reproduction, Vol. I, No. 2, p. 213.

adjustment whereby texts placed on film horizontally or vertically may be read; a lens of good definition and preferrably of short focal length; and a system of holding film flat during projection, with arrangements for moving it from frame to frame without injury.

At the present time there are many wall-type projectors on the market selling at prices ranging from about twenty dollars to several hundred dollars, depending on the facilities desired. The appended chart may serve to illustrate some of the characteristics of these machines. The International Research Corporation sells the Argus projector, manufactured for them by the Society for Visual Education, for $32.50. This low-priced machine is fairly satisfactory, and has been used by many individuals. It will accept 35 mm. double perforate film, double or single frame. The heat problem has not been completely overcome, and attention must be given to the film advancing mechanism. When adapted with a special short focus lens, spool holding and film moving devices, and retractable pressure plates, it may be used satisfactorily by the individual scholar. Mr. Eugene B. Power, of Ann Arbor, Michigan, has offered to furnish these machines, as described, for $42.50, plus transportation.[18] E. Leitz manufactures a wall projector, Model VIII. It is, however, quite expensive. The Umino, a smaller compact unit, may be used for short periods of time, for it tends to warp and buckle the film if used extensively. The Society for Visual Education manufactures a number of so-called "film slide" projectors. Most of these accommodate only single frames, hence, are not suitable for the projection of most microphotographs. The Bausch & Lomb Optical Company has made projectors which might be useful for wall-type projection. "Film slide" adapters

18. See Power, Eugene B., "An Inexpensive Reading Device for Individual Use," in Journal of Documentary Reproduction, Vol. I, pp. 65-69.

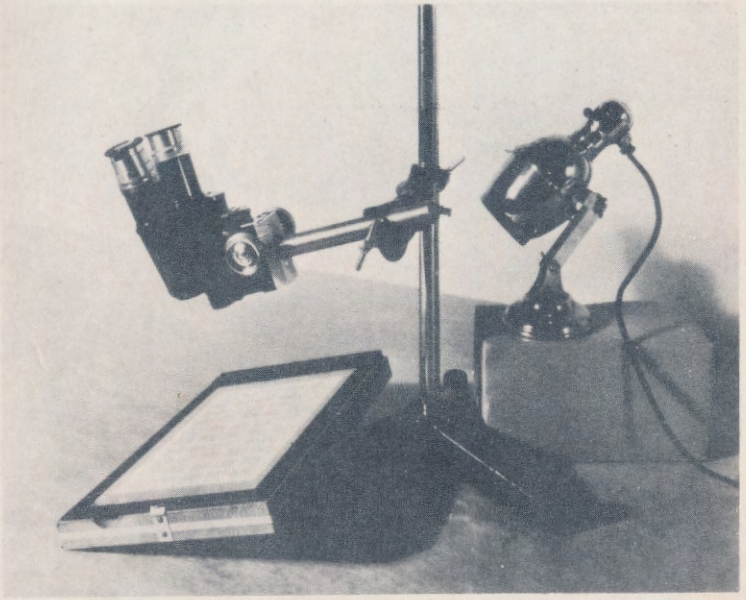

Plate XIV. Bendikson Binocular Microscope Adaptation for reading miniature paper prints.

Chart IV

REPRESENTATIVE WALL-TYPE PROJECTORS

	MAKER	WHERE MADE	POWER OF LIGHT SOURCE	FOCAL LENGTH LENS	FILM SIZE ACCOM-MODATED	FRAME SIZE	RE-VOLV-ING HEAD	FILM MOVED	APPROXIMATE COST	REMARKS
Contabox B	Zeiss-Kion	Germany	100 W	2"	35 mm.	Single Double	Yes	Hand	$84 less lens	Contax camera lens (cost $49.50) employed
Zeiss Large Contax Projector	Zeiss-Ikon	Germany	250 W	4"	35 mm.	Single Double	Yes	Hand	$335 with lens	Uses water-cell cooling; can project 2 x 2" glass slides
Projector VIII-S	E. Leitz	Germany	250 W	Various	35 mm.	Double	Yes	Hand	$60 less lens, film, and slide attachment	Various lenses and attachments for 2 x 2" glass slides available; price with 35 mm. lens and film attachment $104
Udimo 100	E. Leitz	Germany	100 W	Various	35 mm.	Double	Yes	Hand	$45 less lens and film at-tachments	Various lenses and accessories available
Udimo 400	E. Leitz	Germany	400 W	Various	35 mm.	Double	Yes	Hand	$90 less lens and film at-tachments	Water cooled, various lenses
Leica Umino	E. Leitz	U.S.A.(?)	50 W or 100 W	2" (?)	35 mm.	Single Double	Yes	Hand	$45	Small model; fairly satisfactory for limited operation; heat buckles film if used continuously
Picturol Model F	Soc. Visual Education	U.S.A.	200 W	4"	35 mm.	Single	Yes	Hand	$45	Has retractable pressure plates and several adjustments
Picturol Model Q	Soc. Visual Education	U.S.A.	100 W	3"	35 mm.	Single	Yes	Hand	$22.50	Smaller models intended for film slides; 2 x 2" glass slide attach-ment available
Picturol Model BB	Soc. Visual Education	U.S.A.	100 W	4"	35 mm.	Single Double	Yes	Hand	$32.50	2 x 2" glass slide attachment avail-able
Argus	Soc. Vis. Ed. for Interna-tional Re-search Corp.	U.S.A.	100 W	5"	35 mm.	Single Double	Yes	Hand	$52.50	Very similar to above, but marked under name of Argus; 3 and 4" lenses available
Special Adapted BB Picturol	E. B. Power	U.S.A.	100 W	3" or 4"	35 mm.	Single Double	Yes	Hand	$42.50	Has spool holders for 100' spools, re-tractable pressure plates, positive drive for reels

for Balopticon or similar equipment are also sold. The Spencer Lens Company has made up several experimental models. It should be pointed out that it is possible to use some of the paper projection printers or enlargers as wall-type projectors for short periods of time. With some method of heat control these might be converted to good use.

The selection of the best wall-type projector would be difficult. In the first place, it is something of a makeshift, for the darkened room, usually required, automatically excludes many libraries and similar institutions. It must, therefore, be restricted in use, generally, to the individual scholar or scientist, and any improvised machine might be made to serve. E. Leitz has sold many projectors which allow the use of the 50 mm. camera lens. An older model was furnished complete with lens. Probably the best answer to the requirements of the scholar or scientist would be the adapted Argus projector offered by Mr. Power.

Many of the economies which rendered microphotography attractive to commercial firms, librarians, archivists, and others, dealing with records in quantity, have been made possible through the use of the reading machine. A reading machine is basically similar to a projector. It has a protected light source, with suitable optical equipment, provision for moving the film and reading various placements. It overcomes several of the objections to the wall-type projector by having incorporated into the body of the reading machine itself a complete screen, some means to shield this screen from extraneous light, and adequate, easily accessible controls. The reading machine may be used in an ordinary lighted room. In design and ease of operation, it is far ahead of the wall-type projector, but by reason of these refinements, it is, unfortunately, usually quite expensive.

To use a reading machine, rolls or shorter lengths of film are placed in position on the film carrier, and the film-advancing mechanism is used to

move successive frames into position to be read. The images of pages are read on an opaque screen or through a translucent screen. The reading machine allows microfilm materials to be used much in the fashion that books are now used in libraries. A small roll of film may replace several dusty and weighty bound volumes of newspapers. The reader may turn the pages and select this material with a minimum of effort. He may be able to do many times the amount of work which he could have accomplished with the originals through the increased ease of handling.

There are certain disadvantages to the use of reading machines. One of the most objectionable is the inability to compare texts on film, or to consult a microfilm text and, at the same time, refer to a dictionary or other reference book also on film. The inconvenience of doing such work with a single machine is considerable, for one film must be taken out. another substituted, and then the second taken out and replaced with the first. An ingenious method of overcoming this difficulty has been suggested; namely, the possibility of devising a multiple head reading machine. This proposal is entirely practical, but might be somewhat expensive. A former manufacturer of reading machines visualized a solution to this problem and provided removable cartridges of film which could be inserted easily in a reading machine. His plan failed, but a better planned approach might succeed.

Reading machines may serve as wall-type projectors or enlargers. In fact the Argus reading machine features a movable panel which automatically converts it into a wall projector. The same machine may be used for making projection prints on paper by substituting a paper holder for the translucent reading screen. Almost any reading machine may be used for making projection prints on paper by using a sensitive paper holder and making the exposure by turning the projection light on and off. The printing operation must be carried out in a photographic dark

room.[19] The exposed paper is developed in the usual manner. These accessories may permit the reader to make his own notes or excerpts as desired by exposing a piece of sensitized paper in the reading machine.

To date, four companies have marketed reading machines: namely, the Recordak Corporation, the International Filmbook Corporation, Remington Rand, Inc., and the International Research Corporation.

The Recordak Corporation offers the Recordak Model IX for sale at $185. It is intended for reading columnar high ratio reduction material on 35 mm. film, or texts on 16 mm. film. The film surface projected is slightly more than half of a single frame, that is, about 5/8 inch wide by 3/4 inch high. Newspapers on 35 mm. film may be read 1/4 page at a time, and the image on the opaque screen is magnified about 140% of the original size. The lighting system is excellent and the controls are well arranged and easily operated. Film is protected against heat, scratching and other damage. A scanning arm allows any part of the film area to be read. The machine is not particularly satisfactory for reading low reduction material, and some difficulty in scanning newspaper headlines has been reported. Textual microcopies, made two pages to the single frame, with the reading line parallel to the short axis of the film may be efficiently consulted. The Recordak has no satisfactory adjustment for reading material with the text placed parallel to the long axis of the film. A small window allows scanning, but it is inconveniently placed and difficult to use. At an extra cost of about $45, the company will furnish a prism which will rotate the image on the reading screen. For reading high ratio of reduction copies of columnar material, for reading 16 mm. copies, or for reading copies of material especially prepared to meet its limitations, the Recordak is excellent. It does not, however, fill all present needs for reading machines.

19. A recently announced sensitive paper which can be processed in an ordinary lighted room may obviate this difficulty.

Plate XV. Recordak Model IX Library Projector. Note scanning arm at left and coverage of 1/4 full newspaper page on 35 mm. non-perforate microfilm.

Improvements now in process include a newly designed lens with a very flat field intended for smaller magnification on the screen; hence, the machine may be capable of reading lower ratio of reduction copies.[20]

The International Filmbook Corporation placed three types of reading machines on the market, the Optigraphs A and B, both translucent screen models, and Model C, similar to Model B, but with an opaque screen. The market price for Model A, the smaller translucent screen reader, was $95, and for Models B and C, $182.50. In these machines an attempt was made to create a universal low, medium and high reduction ratio reader through the use of supplementary lenses. This principle was never completely successful. Cartridge loading was featured. The machines contained many excellent points but they were never entirely practical. As the company has been liquidated and no successor announced, the products need not be considered further.

A medium reduction reading machine, selling for $75, has been marketed by the International Research Corporation. It is the Draeger Fassin design produced under the name "Argus."[21] Provision is made for holding 100 feet of 35 mm. perforate or non-perforate film on standard spools, a film-moving device intended to preserve the film from scratching while it is being used, a protected lighting system and a translucent screen. Either short lengths or long rolls of film may be used on this machine and a revolving head allows placements with the reading line horizontal or vertical to the long axis of the film. The lens system is intended for ratios of reduction

20. Three types of Recordak projectors may be rented. Models VI (translucent screen) and VIII (opaque screen), for use with 16 mm. film, rent for $2.50 and $5.00 per month, respectively. In some cases Model IX may be rented at $15.00 per month.

21. Described in the Journal of Documentary Reproduction, Vol. I, pp. 79-81

up to 12 diameters, although greater reductions may be read on the translucent screen in reduced size or may be projected on a wall. Although the machine was not intended for use with 16 mm. film, it may be read with some inconvenience. A panel on the front of the machine and a metal bracket on the bottom serve to convert it into an efficient wall-type projector for use in a darkened room. Through the use of these attachments, newspapers and high ratio of reduction copies may be read full size or even enlarged. It is necessary, however, to change the position of the film when the projector feature is used, for the elimination of two reflecting surfaces causes the machine to throw a reversed image when the film remains in the position used for the translucent screen. The Argus reading machine has proved to be quite satisfactory for small library, scholarly and scientific use, although it has certain limitations for extensive library and business purposes. It may be obtained from three sources. For a limited time, Science Service in Washington, D.C., will distribute it on order. The maker, International Research Corporation, will also fill orders. Commercial distribution arrangements have been made with the Folmer Graflex Corporation, of Rochester, New York.

Remington Rand, Inc., has developed a reading machine for use with the Film-a-record camera. It accommodates 16 mm. film only and is of the opaque screen type. A separate lamp house projects light through the film into the hood which covers the reading screen where a mirror reflects the image downward. Advance and retraction of the film is achieved through cranks on the side of the machine. It is intended for commercial use and is less perfected than the Recordak Model IX which it resembles in outward appearance. The cost is $180.

The Recordak Corporation has been active in placing large plans, blue prints and similar material on film for industrial and business concerns. In order that they may be used efficiently, a large plan

Plate XVI. Argus Reader.

Plate XVII. Argus Reader used as a wall-type projector. Note position of base and raised flap on projection head.

Plate XVIII. Film-a-record Reading Machine.

Plate XIX. Recordak Large Reading Machine for blue prints, plans and similar material on microfilm.

reader has been perfected. It is in reality a translucent screen reading machine with a very large inclined screen on which a draftsman may work almost as if he were using an illuminated tracing table. A light source of approximately 750 watts intensity is employed, and an automatic electric blower keeps the film and lamp house cool. Light is projected downwards to a mirror which reflects the image upward to the reading screen. Film advance and retraction are remotely controlled by a crank placed beneath the reading screen at the right side of the machine. An indentation is provided at the bottom of the assembly in order that the reader may work more efficiently. In operation, film is loaded on reels placed near the lamp house, and the reader makes all subsequent adjustments from the front of the machine. Only a few of these readers have been built to date and they have been used principally for blue prints and similar materials. There is no reason, however, why very large folio volumes, newspapers and similar printed matter on film could not be read full size on this machine. It is quite heavy and may be classified as non-portable. At the present time this machine is only built to order at a price of between $500 and $750. The unit cost will probably be diminished if the design can be placed in production.

Several firms and individuals are engaged in developing reading machines. The Society for Visual Education has built several test models intended for the low-cost field. The Folmer Graflex Corporation has also experimented, but since the advent of the Argus has discontinued work for the present. Bausch & Lomb also investigated the possibility of developing the Draeger machine, but did not go ahead with their plans. Some work has been done by Holbrook Microfilms, but details have not yet been made public. Probably the most significant development in the entire reading machine field, however, is that of the Pathé Film Corporation of New York. A revolutionary new lens, with other equipment now being completed,

allows the projection in a reading machine of low, medium, and high ratio reduction microcopy, and the enlargement of the image to any size desired between 14 and 40 diameters. If, for instance, a newspaper on film were projected on a screen at a magnification of about 14 diameters, headline scanning and column title reading would be possible. By moving a lever, any selected portion of the text may be enlarged up to or beyond natural size. Further details and date of appearance are not obtainable, but it seems certain that this machine will be quite expensive, selling for at least $350.

A summary of the reading machine problem is discouraging. In the very field where greatest benefits to microphotography from special equipment could accrue, progress has been painfully slow. Little selection is now possible. Films must be made to fit one of the available reading machines, or be read on wall-type projectors, or made into paper prints. It is true that many developments are in prospect, but these have not yet reached the market, and their advent cannot be definitely predicted.

Reading machine users fall into three general groups: commercial concerns, libraries and similar institutions, and individuals. The first group is satisfied for the time being with rented or purchased equipment, and in some cases by special equipment built to order. Libraries and similar institutions need several kinds of machines for the use of inexperienced readers. They must be as nearly foolproof as possible, and also adaptable for many kinds of copies. Equipment can now be obtained for certain types of work, but the requirements of this group are not completely met. The individual scholar or scientist may find that the new Argus reading machine will prove adequate for his purpose. Those unable to invest $75 must perforce be content with a wall-type projector, or even with paper prints, or perhaps evolve their own adaptation of some other piece of equipment.

POSITIVE MICROFILM PRINTS

Many, if not the greater number of microfilms, are used in negative form. This may be accounted for by the comparative newness of the application of microphotography to modern problems, and by the fact that negative film files of universal appeal have not yet been accumulated. Large-scale projects with several sponsors, however, have created a demand for positive prints for use in different institutions or locations. A typical example of a cooperative venture of this type is the work being undertaken by University Microfilms, of Ann Arbor, Michigan, in filming English books printed before 1550. Positive copies are being distributed to 16 leading libraries in this country. Over 40 daily newspapers are being microfilmed by the Recordak Corporation, and in most cases positive copies are also being made. When files of negatives accumulate in libraries, archives or other central agencies, and film copies of these negatives are requested, positive printing equipment will be required.

Microfilm positives are usually intended for use in a reading machine, or wall-type projector. They show the image as it appeared in the original with the correct relationship between text and background. In a positive microfilm of this page, the text would be black and the background white.

Positive film prints may be obtained from commercial film printing laboratories, or from libraries and other institutions equipped with facilities in their own laboratories.

Commercial film printing services are of two types: special and general. At this time only a few firms are equipped or interested in offering specialized service for the printing of microfilm negatives. Mr. Eugene B. Power of University Microfilms, Ann Arbor, Michigan, has indicated that he may undertake this work. The Ozaphane Corporation, of Stamford, Connecticut, will print microfilms on acetate base ozaphane. The American Documentation Institute of

Washington, D.C., is now equipped to furnish positives from microfilm negatives. The Eastman Kodak Company prefers to print negatives made on Recordak equipment, but will, on occasion, print other film. Prices vary with the nature of the negative and the number of sets of prints required. The general service offered by motion picture positive printing firms has been used for microfilm printing from time to time. Prices are generally lower than those of the Eastman Kodak Company, but the work is usually inferior on account of the different technique used for printing microfilms from that for motion pictures.

Equipment for making positive film prints is of two types: optical and contact. The former is rarely used, hence, will not be considered at this time. Contact printing equipment is subdivided into continuous and step printers. The continuous printers require the unexposed film and negative to pass in contact before a light source at a measured rate of speed. Step printers require the unexposed film and negative to come to a full stop while the exposure is being made.

Most of the positives used at this time are made on amateur step printers or commercial motion picture printers. The former type is represented by the Leitz positive printer, which is sold for about $100. It has light control and provision for making glass slides. An example of the commercial motion picture printers is the Stineman. It is small and compact, and will make good prints if carefully managed. Intended originally for motion picture work, it may be obtained for either 16 or 35 mm. film. A hand drive is furnished, and a motor drive may be easily fitted. The list price of this machine is $90. A motor driven printer of larger capacity is the Arri printing machine. It is made in France, and is available for either 16 or 35 mm. single frame film. Although it is small in size, many controls and refinements fit it for producing accurate work. The approximate price of this machine is $150.

Plate XX. Making Contact Microfilm Prints on the Stineman continuous printer.

The Bibliofilm Service of the American Documentation Institute has just acquired a printer for microfilm materials. It is a converted motion picture printer which has been rebuilt to accommodate 35 mm. double frame originals. Many controls and refinements permit old and newly made negatives to be printed irrespective of possible shrinkage or distortion. A special printer of unique design has been built by Ozaphane, Inc., but as it is intended solely for use with that material and is not commercially available, it need not be discussed at this time. A few experimenters have built special printers to meet particular demands.

To many, if not to most, centers of microfilming, the problems incident to printing microfilms remain a closed book. At the present time there is no equipment which will permit any institution to make its own prints in quantity, hence, duplicates must be procured on contract from the few centers prepared to render the service. Further experimentation should be encouraged and special equipment for printing microfilm positives should be designed.

INDEXING DEVICES

Microfilms must be indexed in order that the material contained on a given roll may be located and used easily and rapidly. This is particularly true when miscellaneous material is being copied. The complexity of the indexing problem varies considerably with the nature of the copies made and the extent to which it is desired to prepare them for use. Indexing may be divided into two classes: identification and page locating. Identification consists of photographing or affixing (preferably the former) some means of identification on the roll or strip of microfilm. This identification usually consists of the source of the material, and some portion of a scale or rule. It is customary to place identifications of this type at the beginning and the end of each roll, but it is better to film an abbreviated notation on

each frame of film taken. These notations may be keyed to a card index or other device for locating the desired material.

Page, or item locating, is much more complicated. There have been several plans proposed and some of these placed in operation. The International Filmbook Corporation experimented extensively with the Teledex type of identifying device for use with telephone indexes, city directories, and library card files on film. The material was carefully photographed in rows, and large index letters, changing gradually as the materials changed, were included on the film in a predetermined location. When the completed film was placed in a reading machine, called in this case the Teledex, a rotating prism picked up the large index letters, and caused them to appear almost stationary on the reading screen, while the balance of the material was being moved rapidly. This system was called stroboscopic indexing, although in operation it did not conform to the accepted principles of the stroboscope. Some interesting results were achieved, but this scheme has not yet been perfected. Another plan, developed by Mr. Merle C. Gould, now associated with the Automatic Signal Corporation, was intended initially for use in classifying and finding fingerprints. Photo-electric cells, in conjunction with a keying system incorporated on the original microfilm, would permit machine selection of predetermined classification types. In later designs the machine has been expanded so that it may be used in much the same manner that punch card tabulating machines are now being employed. Selector and automatic printing equipment have been devised, and it is projected that an investigator may set up the machine to search a file of cards, or other information on film, and receive a complete file of photographically printed cards, all produced automatically. The preliminary models showed considerable promise, and further investigation is being undertaken. Mr. L. Townsend, of Washington, D.C., has been granted

several patents on automatic microfilming equipment in which automatic selection devices have been incorporated. As yet no models have been built, however. Dr. R. H. Draeger has also been granted two patents, one on a camera-indexing mechanism, and the other on a page finder. In his absence little information is available about these items.

One more or less common method of locating material has been used by individual scholars. A file of correspondence is placed on film. Individual letters or documents are then cut into short strips and filed in small envelopes, which are indexed to a card file or other similar device. The location of an item is thereby facilitated, but the short strips, in some cases merely a single exposure, are sometimes misplaced, and are awkward to use in reading machines.

In the book project of University Microfilms, previously referred to, several books are included on a single roll of film. A catalog card is made up, however, locating the item on the roll in relation to the other material.

At The National Archives a file of some 2,600,000 index cards were placed on film and keyed to numbered "flash" indicators placed about every hundred cards. By locating a desired name in a bracket between two of these numbers (which is achieved by a list of names on the outside of the container for the roll), the film-advancing mechanism may be rotated rapidly and the card located within a bracket of 100 cards. It is then a simple matter for the exact card to be found. In its present hand state, the file may be used on film as rapidly as the original card file, and plans exist for motorizing the consultation system in order to make reference easier and more automatic.

An indexing system should preferably be devised before the film is made. It is possible to combine identification and page location in most cases, and every effort should be made to prepare a microfilm which will be as usable as the original itself.

In the case of bound volumes, the catalog card may be filmed before the volume is photographed or suitable notes on a card may be made for filming. It is sometimes advantageous to include a small portion of a scale or rule on the film so that the size of the original may be accurately determined. It is only necessary to enlarge the document until the scale (whether it be in inches or centimeters) corresponds to a similar scale in order to be certain that the document is exactly original size.[22] This may be important in critical bibliographical collations. It has also been found convenient in the case of bound volumes to film the index and table of contents both at the beginning and end of the roll of film, for it is then possible to consult both index and table of contents without the necessity of advancing the film to the end thereby expending some time and subjecting the film to additional wear. Manuscripts, having no numbers, should be numbered. An old calender provides excellent numerals for this purpose. Page location and checking is immensely facilitated if this is done.

The problem of indexing and page location requires some attention, and as microphotography increases in use, will become more important. The subject should be thoroughly investigated; and a research study of possible processes and applications would undoubtedly result in the accumulation of information of great value.

STORAGE

The storage of microfilms is not a difficult problem, provided they have been made on acetate film. The National Bureau of Standards has conducted extensive investigations into theories of storage, and concludes that the principal factor to be considered is humidity. Extremes of temperature should be avoided. For all practical purposes acetate microfilms may be stores at ordinary room temperatures, 70-75 degrees

22. Small photographic errors and shrinkages may be neglected.

Fahrenheit, if sufficient humidity is maintained. About 50% relative humidity is considered adequate. Optimum conditions for long-time storage have been stated to be 50° Fahrenheit and 50% relative humidity, but the application of this theory involves certain practical objections. Film stored at 50° and brought into a warm room has a tendency to acquire moisture or "sweat." This must be carefully guarded against, and film brought from cold storage into warmer reading rooms should be tempered or brought gradually up to room temperature. Storage containers should be designed to permit easy access to the contents and to protect the film against the effects of careless handling.

Containers for microfilms are of two general classes: those for roll films, and those for single units or short strips. At the present time rolls of microfilm are commonly stored in containers made of cardboard, tin or other material. At the New York Public Library 100-foot lengths of newspapers on 35 mm. film on reels are enclosed in individual containers and then six of these are placed in a large case which is shelved on a regular library shelf, just as a large folio volume would be. The Recordak Corporation delivers its newspaper film on reels in cardboard boxes with folding flaps. The National Archives stores film in metal-edged cardboard boxes which telescope together. Long lengths of film may be stored on reels, while shorter lengths may be stored on a metal or wooden core. A combination demountable reel to accept these cores for projection is needed.

At the present time, the general theory of long-time storage is that the film should lay with the weight on the edges rather than on the convolutions. The humidified atmosphere should also have free access to the film. If metal cans are used the lids should be left loose or off. It must be noted that metal, if not sufficiently protected in high humidity, has a tendency to rust or corrode, and damage the film.

Several companies have made up humidified and non-humidified cabinets for storing microfilm. Remington Rand, Inc., and Yawman and Erbe have prepared or adapted equipment for this purpose. The Neumade Products Company have made up an experimental storage unit 15 inches wide and 12 inches deep. It has six drawers about 1 1/2 inches deep. A series of movable partitions allow the storage of either rolls or strips. The present unit is not humidified, but plans are under way to install humidifying devices in subsequent cabinets. The present cabinet sells for $40.

Short lengths of microfilms are stored in a variety of ways. The Contax film wallet intended for strip films of scenic subjects is frequently used. It consists of a folding transparent paper envelope with six compartments open at each end, about 1 3/4 inches wide by 9 inches long. These hold 36 double or 72 single frame exposures, and retail for 50 cents per dozen envelopes. A system of notation by subject is printed on the back of the heavy paper-protecting wallet. Many other similar holders, some spiral bound, are available from photographic supply houses which cater to miniature camera users. Dr. Atherton Seidell has designed a looseleaf folder for holding and indexing short strips of film containing scientific articles.

Considerable progress is reported in the manufacture of durable transparent envelopes. These may be important in unit storage, for the delicate emulsion face may be protected against damage, and the film may be used in a projector or reading machine without being removed from the envelope. At The National Archives, some preliminary experiments have been undertaken in the lamination of microfilm with thin sheets of cellulose acetate foil. The first samples have not been particularly satisfactory, but the process may be practicable when certain initial difficulties have been overcome. In sealing the negative in acetate foil, it is protected from damage through handling and use, and is much easier to store.

However, this process appears to be suitable only for short strips or units.

THE PATENT SITUATION

Considering the patent situation in microphotography from the viewpoint of the layman, several factors are evident. The basic principles of microphotographic cameras, processing machines, wall projectors, and reading machines do not appear to be patentable. Approaches to particular problems, especially methods of holding and moving originals, operation cycles, indexing mechanisms and the like, have received much attention at the patent office. Two schools of thought prevail. One holds that most of the mechanisms are not patentable, hence, does not attempt to patent entire machines but only certain features. The other hastens to the Patent Office with applications for complete coverage of all claims. What the situation will be ten years from now is uncertain. If the technique continues to expand in business, and large, well-capitalized companies appear, patent litigation is almost certain. Only one comparatively large-scale lawsuit over microphotographic patent rights has been taken to the courts, and the decision is said to have been rendered for the defendent. A study of the patent situation, by competent authority, would doubtless bring to light many interesting factors, and might be decidedly worth while.

COST ACCOUNTING IN MICROPHOTOGRAPHY

Cost accounting in microphotography has not received sufficient attention. The process is so inexpensive that little effort has been made to obtain exact figures. Also the nature of the technique and its application, the many variable factors and the optional alternative procedures render a cost figure exceedingly difficult to compute. Among these may be listed:

(1) Variation in nature and format of originals and in the kinds of copies which can be made from them.
(2) The kind of film and processing required.
(3) The ratio of reduction in terms of probable use.
(4) The number of pages to be copied and the number of copies desired.
(5) Overhead including personnel, equipment, obsolescence.
(6) Copying in the field or in a laboratory.
(7) The cost of servicing originals to the camera.

Originals may be bound or unbound, large or small, printed or manuscript, drawn, painted or objects of three dimensions. From these, contrast, full tone, corrected or full color microcopies may be made. The film used, and the processing required, must be related to the type of original and the kind of copy to be made. The ratio of reduction, by allowing more or less textual matter to be placed on a given length of film, vitally affects the cost of the process. If many copies, including both negatives and positives are required, the overhead charges may be apportioned, thereby decreasing the cost per set. Overhead includes such items as labor, equipment, space rental, heat, light, water, electricity, etc. Location affects cost of reproduction, for, as a general rule, copying in the field is more expensive than copying in the laboratory. The cost of servicing originals to the camera includes all charges for correspondence, accounting, delivery and reshelving or storing.

In his "Manual on Methods of Reproducing Research Materials," Professor Robert C. Binkley[23] discusses some of the problems involved. He presents tables and figures which deal with the cost per square

23. Binkley, Robert C., Manual on Methods of Reproducing Research Materials (1936), pp. 121-134.

inch of the processed sensitive area in terms of ratios of reduction and legibility. Even in the short interval which has elapsed since his book appeared, technological advances and greater experience have made some revision of his conclusions and studies necessary.

One of the vital factors in determining the cost of microfilming is the ratio of reduction. This may be defined as the number of times a given original must be reduced in order to place it on film. A book page 6x9 inches in size may be reduced six times on double-frame 35 mm. film, eight pages to the foot, which when processed costs (excluding overhead, labor and servicing costs) about $.02, or a unit cost of $.0025 per page. If reduction ratio is increased to nine times, 16 pages may be placed on one foot of film for the same price, or a unit cost of $.00125. If the reduction ratio is further increased to twelve times, then 32 pages may be placed on one foot of film, and the unit cost per page would be $.000625. Ratio of reduction, however, is dependent on the size, form, and condition of the original. Lower ratios of reduction must be used with poor copy.

There is, as yet, no concrete definition of quality in microfilming. Some terms borrowed from sensitometry are in use. For example, gamma is frequently used to refer to contrast, but it is merely a position on a curve in which density is plotted against the log of exposure. A crude working definition of an "ideal" microfilm is, namely, one which can be enlarged back to original size on paper without noticeable loss in sharpness at normal reading distances. In determining the ratio of reduction, therefore, it is imperative that this definition be considered. It is not always necessary to achieve an "ideal" result, for copies of originals may serve quite well for some purposes in a less perfect form.

The application of microphotography to scholarly, scientific and business requirements will be conditioned to a great extent on accurate cost figures.

At this time it is suggested that each individual or institution undertaking microphotographic work should keep accurate cost records.

GENERAL SUMMARY

The foregoing survey of the present status of equipment and supplies for microphotography supports the assertion that this phase of the technique is well advanced. Equipment exists which is being used for an infinite variety of projects. The utility of the process has been proven, and the safety of the product is assured. Interested parties may secure, by purchase or rental, apparatus which will cope successfully with practically any problem. Intensive use and application are possible and necessary as a prelude to further progress.

Theoretically, however, microphotography is almost an enigma. Present-day achievements have followed a few well-marked paths. Experimenters confronted with definite problems have armed themselves with photographic knowledge, scientific equipment, mechanical skill and imagination and are blazing trails toward their individual objectives. It is as yet uncertain whether pathway or trail will become the highway of the future.

ABRIDGED DIRECTORY OF SOURCES OF FURTHER INFORMATION[24]

Agfa Ansco Corporation
Binghamton, New York

American Documentation Institute
c/o Department of Agriculture Library
Washington, D.C.
Mr. Cuthbert Lee, Director

American Library Association
Committee on Photographic Reproduction of Library Materials
Robert C. Binkley, Chairman
c/o Western Reserve University
Cleveland, Ohio

Bausch & Lomb Optical Company
Rochester, New York
Dr. W. B. Rayten

Bell & Howell Company
1801 Larchmont Ave., Chicago, Illinois
Mr. R. Fawn Mitchell

Bibliofilm Service. See American Documentation Institute

Bureau of the Census
Department of Commerce
Washington, D.C.
Dr. T. F. Murphy

24. Committees, individuals, institutions and manufacturing concerns are listed. In some cases notation is made of the individual to whom correspondence should be addressed.

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29 Rue Aux Laines
Bruxelles
Andre van Remoortel

Committee on Scientific Aids to Learning of National Research Council
41 East 42nd St.
New York, New York
Dr. Irvin Stewart, Director

Dr. R. H. Draeger
U.S. Navy, Medical Corps
c/o Navy Department
Washington, D.C. (mark letters Please Forward)

Du Pont Film Manufacturing Corporation
9 Rockefeller Plaza
New York, New York

Eastman Kodak Company
343 State St.
Rochester, New York
Mr. C. Z. Case

Folmer Graflex Corporation
154 Clarissa St.
Rochester, New York
Mr. A. R. Barker, Photorecord Department

Fotokopist
Berlin S.W. 68
Alte Jacobstrasse 11-12

Haloid Corporation
Haloid St.
Rochester, New York

Holbrook Microfilms, Inc.
33 West 60th St.
New York, New York
Mr. John K. Holbrook

Holloway Company
72 Spring St.
New York, New York
Mr. Jack Holloway

Hollywood Roto-Tank, Ltd.
5225 Wilshire Blvd.
Los Angeles, California
Mr. Roy Davidge

Henry E. Huntington Library
San Marino, California
Dr. L. Bendikson

International Research Corporation
112 Williams St.
Ann Arbor, Michigan
Mr. B. D. Gilbert

Joint Committee on Materials for Research
c/o Western Reserve University
Cleveland, Ohio
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Photoduplication Service
Washington, D.C.
Mr. George A. Schwegmann, Jr., Director of the Union Catalog and Photoduplication Service

Mr. Frederick C. Ludwig
c/o Yale University Library
New Haven, Connecticut

The National Archives
Division of Photographic Archives and Research
Washington, D.C.
Vernon D. Tate, Chief

National Bureau of Standards
Washington, D.C.
Dr. B. F. Scribner, Chief, Paper Section

National Microfilming Company
Concord and Day Streets
South Norwalk, Connecticut
Mr. V. E. Pratt

Neumade Products Company
440 West 42nd St.
New York, New York

New York Public Library
5th Ave. and 42nd St.
New York, New York
Mr. R. H. Carruthers, in charge Microfilm Service

Ozaphane, Inc.
18 Elmcroft Road
Stamford, Connecticut
Mr. J. R. Balsley

Pathé Film Corporation
30 Rockefeller Plaza
New York, New York
Mr. Robert B. James

Photostat Corporation
Rochester, New York

Recordak Corporation
350 Madison Ave.
New York, New York
Mr. John K. Boeing

Record Registry Corporation
912 East Washington St.
Indianapolis, Indiana
Mr. J. Q. Kerrins

Remington Rand, Inc.
465 Washington St.
Buffalo, New York
Dexigraph Division)
Film-a-record Division) Mr. Preston B. Porter

J. G. Saltzman, Inc.
480 Lexington Ave.
New York, New York
Mr. J. G. Saltzman

Science Service
2101 Constitution Ave.
Washington, D.C.
Dr. Watson Davis

Dr. Atherton Seidell
c/o United States Public Health Service
Washington, D.C.

Society for Visual Education, Inc.
327 S. La Salle St.
Chicago, Illinois
Mr. B. J. Kleerup

Spencer Lens Co.
19 Doat St.
Buffalo, New York

R. P. Stineman, Inc.
918 Sunset Blvd.
Los Angeles, California

University of Chicago Microfilming Service
c/o University of Chicago Libraries
Chicago, Illinois
Dr. M. L. Raney, Director
Mr. H. H. Fussler, Technician in charge

University Microfilms
313 N. First St.
Ann Arbor, Michigan
Mr. Eugene B. Power

W. Watson & Sons, Ltd.
313 High Holborn
London, W.C. 1

Carl Zeiss, Inc.
485 Fifth Ave.
New York, New York